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The Kent Incorporated Society for Promoting Experiments in Horticulture

ANNUAL REPORT

(TWENTY-THIRD YEAR)

1935

EAST MALLING RESEARCH STATION

EAST MALLING

KENT

IMPERIAL MYCOLOGICAL
34 AUG. 1936
INSTITUTE

1st January, 1935 to 31st December, 1935

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FOR PROMOTING EXPERIMENTS IN
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Goods Station: Aylesford (Southern Railway).

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FROM MAIDSTONE by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to East Malling Church.

FROM LONDON a regular service of Maidstone and District Coaches from the London Coastal Service Limited, Victoria Station, may be of assistance to Visitors. The Coaches call at East Malling on certain inward and outward journeys.

For Visitors coming by road DITTON CORNER on the main London-Maidstone Road (with Red Lamp Danger Signal) is the turning to the Research Station.

Telephone: Aylesford 7229.

Telegrams: *Research, East Malling.*

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is accommodated at East Malling Research Station.

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EDITORIAL

THE Station's Annual Report is again published in two parts. That dealing with the general development and activities is presented by the Executive Committee to the Annual General Meeting ; it is printed as a Supplementary Report mainly for the use of our Committee and Members and is circulated separately to our Members.

The Annual Report of research work is made up of four sections as follows :

I. The Experimental Farm.
II. General Review of Research Work, with Summaries of Papers published during the Year.
III. Preliminary Research Reports.
IV. Bulletins for Fruitgrowers.

The General Programme of Research Work has been revised during the year, and the numbers accompanying the projects set out in Section II correspond to those in that programme. This Section includes complete lists of papers published by the staff during 1935, together with summaries of those papers not readily accessible to our Members. Papers published in our Annual Report for 1934 are mentioned in the lists but not summarized since they are either already in the hands of our Members, or can be purchased from the Station.

Dr. Wormald has undertaken to be general Editor of this Report, but heads of Sections are responsible for the sectional reports.

AN APPRECIATION

LORD CORNWALLIS OF LINTON

Deceased 26th September, 1935

The Governing Body and the Executive Committee sustained a great loss in the death of Lord Cornwallis, but everyone at the Station felt that they had lost a true friend and ready counsellor. From the time when Wye College was considering the founding of a fruit experiment station, Lord Cornwallis was encouraging the idea not only by material assistance but by giving his advice and using his influence with the County Authorities to play their part in the finance of the Station. Probably many members do not realize that Great East Field (the original Research Station) was purchased as a result of his advice by the Kent County Council and has been let ever since to East Malling Research Station for experimental work, on a "pepper corn" rental, nor do they know that on two later occasions it was only through his personal tact and advocacy that East Malling was enabled to continue its normal expansion. It was, again, on his representation that the County originally made its annual grant towards the Station's expenses. When the Station was going through its worst financial crisis Lord Cornwallis was prepared, in spite of all the other calls upon him, to take his share with other members of the Committee in guaranteeing the Station's overdraft, and when the various appeals for capital funds went forth, without ever being approached, he was always amongst the first to head the subscription lists. Despite all his other public work in the County it was very rarely that he missed the Quarterly Executive Meetings at East Malling and when any matters of procedure or particular importance arose his advice was always sought and readily given. Few people appreciate the amount of detailed thought which an event such as our Twenty-first Anniversary involved, and they will certainly never realize the part played by Lord Cornwallis in helping to make the arrangements run smoothly in every detail. Only a week or so prior to his fatal illness he willingly discussed in detail all the important aspects of the revision of the Station's Articles of Association with his usual clarity of mind although obviously a sick man. His loss has left a gap that will indeed be difficult to fill.

Section I

THE EXPERIMENTAL FARM

By J. AMOS, F. H. BEARD, M. H. MOORE, A. C. PAINTER, and B. L. WATES,
with introduction by R. G. HATTON

Introductory.

We would make no apology for once again repeating the remarks which have formed the introduction to this section of the report in previous years, as it is very necessary to bear them in mind when considering the results obtained.

The total area of the Research Station is now approximately 150 acres (Great East Field 22 acres, Egham Field 40 acres, Church Field 20 acres, Newgates Field 25 acres, Upper Grub and Newgates Shaw 13 acres, and, in addition, rented pieces in Kiln Field 18 acres and Deadman 12 acres). However, quite a considerable proportion of the area (approximately 12 acres) is occupied by buildings, approaches, innumerable headlands to comparatively small experimental plots and even to planted areas which can never be commercially productive (approximately 6 acres). In addition, many of the plantings (approximately 40 acres) are still quite young and are producing no returns. Again, varieties of problematical commercial value have frequently to be deliberately chosen for planting in order to study the very troubles for which the grower is seeking an explanation. Finally, even amongst the yielding areas there are inevitably the "control" plots, the unpruned, unsprayed, unmanured, etc., which bring down the standard of the whole. The picking and marketing is often complicated by the very large number of varieties grown and the small plots into which many of the trials are divided, e.g. strawberry and raspberry trials may consist of as many as 300 to 400 separate plots, each of which has to be picked and recorded separately, thus appreciably increasing the cost of picking and the amount of handling, which, in its turn, renders it difficult to get the fruit on to the market in the best condition.

Owing to all these experimental exigencies it is only on comparatively small areas that our own ideal routine of cultural and spraying methods can be carried out. We would ask our grower readers to bear all these foregoing facts in mind in judging the results on an experimental farm. East Malling must not be looked at as a farm mainly demonstrating how things should be done ; only too often the right ways can only be found out after eliminating a succession of wrong ones, and it yet remains for some Educational Authority to demonstrate on a commercial scale the combination of right findings of research and put them in their economic frame. This point of view is being emphasized because we believe that our annual report on the farm can profitably be developed in some detail, provided it is realized that we are not claiming to tell the story of a commercial holding run on up-to-date lines, but merely to state in terms of market value some of the experiences gained from sale of fruit from our experimental plots.

(R.G.H.)

FARM REPORT

Cultural.

Although rain fell on some fifteen days during January, the total amount was low and did not interfere with outdoor operations, except, in the case of winter spraying which was not completed until the middle of February. Mild and very wet conditions prevailed throughout February, and towards the end of the month the early flowering Myrobolan cherry plums were in full flower, which is the earliest record at this Station for this variety. During March weather conditions were sunny and dry and this helped forward all early spring cultivations. April was a month of heavy rainfall but with considerable bright periods ; this favoured growth and by the end of the month many of the earlier fruit were opening their blossom. Whilst the conditions during May were for the most part dull and cold a temporary warm spell around the 6th rapidly brought into flower most varieties of apples. This was followed by a very cold spell and on the night of 16th-17th, 12 degrees of frost were registered which completely destroyed what in many cases gave promise of heavy yields. Continued cold drying winds also did further damage to any remaining blossoms and fruit. Most top fruits were a complete failure. Bush fruits were partially affected, especially the later flowering sorts, which happened to be in flower at the time, and in the case of raspberries and strawberries it was only the later flowers which developed. It was not until the latter end of June that summer conditions were experienced. The warm weather continued during July which was the driest month of the year. At this period it was noted that although the total rainfall was well up to the average for the year, many plants showed symptoms of wilting, which was severe in the case of strawberries and also upon some of the tree fruits. This hot dry spell favoured the rapid spread of the Fruit Tree Red Spider. Similar conditions were experienced during the greater part of August but towards the end heavy rainfall was experienced. September was a very wet month and this hindered the gathering of the hop crop, which was also badly damaged by the strong south-westerly gales on the 16th and 17th. Both October and November were again months of heavy rainfall, during the latter month 5·75 inches being recorded.

During December some frosty periods occurred but for the most part it was wet and made outdoor operations difficult.

Fresh Plantings, Grubbing, etc.

Great East Field.—No further grubbings or fresh plantings have taken place during the past year. All the eighteen-year-old trees of Worcester Pearmain on different rootstocks which were transplanted last year have survived. The one acre that was cleared of trees last winter has been sown with vetches, and has now been prepared for the planting up of strawberry trials.

Egham Field.—On this field two pieces of land have been cleared ; an acre of stool beds has been transferred to the main beds on the Newgates Field, and another acre of twelve-year-old apple trees has also been grubbed.

The former has already been planted with strawberry trials and the other, sown with vetches for green manuring, will also be used for further strawberry trials. On Plot 35 the seven-year-old black currants have been taken out to give room for the young bush apples with which they were interplanted two seasons ago. In addition to these areas half an acre of old strawberries has been cleared and will be planted with nursery trials.

Church Field.—The acre that was prepared for the trials of loganberries and blackberries has been planted with clonal material raised at this Station, and will be used to test out different methods of training in conjunction with various spraying treatments.

Newgates Field.—The five acres of four-year-old strawberry plants were ploughed in immediately after fruiting and sown to Victor Wheat in October. The young strawberry plants between the black currants were also removed in order to avoid risk of infecting with disease new plantings of healthy runners in adjacent fields.

Upper Grub.—A big supply of runners was obtained from the acre planted with disease-free runners in 1934, and from these a further eight acres have been planted out for further runner production. In addition a number have been used for other experimental plantings and for distribution to members.

Kiln Field.—A further number of inferior varieties on this field have been stub-grafted to Miller's Seedling and it is hoped eventually to thin out or "over-work" the remainder of the unprofitable varieties.

Deadman.—This is a new twelve-acre field that has been obtained during the past year, principally with the idea of providing land upon which to test out on a field scale many of the results of our recent investigations upon strawberry problems. Three acres are already planted with four-year-old Giant Prune plums, the remainder being arable. The whole of these nine acres, which was until quite recently planted with hops, was ploughed and sown with spring oats. Six acres of this have again been sown with winter oats and the other three acres planted up with virus-free strawberries for runner production. (J.A.)

Marketing.

As regards marketing there is unfortunately little to record. Top fruits were almost entirely wiped out by frost and the yield of most soft fruits greatly reduced. The extent of the damage can be seen from a comparison between the quantities marketed in 1934 and 1935.

	1934.	1935.
Strawberries	6½ tons.	2 tons.
Raspberries*	3¼ ,,	4¾ ,,
Gooseberries	5½† ,,	5¾ ,,
Red Currants	2 ,,	2½ ,,
Black Currants	7 ,,	2½ ,,
Cherries	9 ,,	1½ cwts.
Plums	40 ,,	1¾ tons.
Pears	930 bushels	150 bushels.
Apples	11,500 ,,	130 ,,

As was to be expected, prices were generally high, but this did little towards compensating for the loss of crop. Wherever quoted, prices are those obtained for

* Owing to the grubbing of an old plantation and the coming into cropping of a new area no direct comparison is possible between the two years. An average crop for 1935 would have been between 8 and 9 tons.

† Between ¾ ton and 1 ton of Whitesmith were left unpicked.

the main crop, odd consignments at the beginning and end of the season not being taken into account.

The total gross receipts from fruit for the 1935 season amounted to £920, against some £6,500 in 1934.

In view of the increasing amount of work devolving on the marketing section Miss B. L. Wates was transferred from the recording staff in the early summer as assistant to the Marketing Officer. As, however, there was no apple and pear crop to deal with the opportunity was taken for her to obtain a thorough insight into commercial grading and packing on a large scale; this was effected through the kindness of Mr. Spencer Mount, Mr. T. Neame, Mr. W. Brice and Mr. E. F. Guthrie.

Individual Crops.

Strawberries.—(Area under cultivation—4¾ acres in Newgates Field in their fourth year, rather more than ¾ acre of which had been originally de-blossomed and used for runners. About 1 acre of two-year-old plants, also in Newgates Field, interplanted between black currants. In addition two small experimental plots in Egham Field, comprising about ½ acre in all. The plantings consist of Royal Sovereign.)

The early blossom, from which the largest fruit is usually obtained, was almost entirely destroyed by frost. The 4¾ acres in Newgates Field only yielded approximately 23 cwt. and the 1 acre of two-year-old plants 12 cwt. Of this only some 350 lb. was up to National Mark Standard, the remainder having to be marketed as small or jam fruit. Prices—as was to be expected from the short crop—ruled high.

The crop was marketed as follows :—

Under the National Mark Label.

"Selected" in 3 lb. chips—350 lb. Price 8d. to 1s. 2d. a lb.

Under Own Label.

Small fruit in 3 lb. chips—1,120 lb. Price 5d. to 8d. a lb.
Jam fruit in tubs—2,220 lb. Price 5·4d. a lb.
Ungraded and blemished—220 lb. Price 4½d. to 6d. a lb.

The gross amount received was approximately £100 or £58 a ton.

The experimental plots in Egham Field only yielded 4 cwt. of marketable fruit for which the sum of £12 was obtained.

Raspberries.—(Area under cultivation—about 4 acres of two-year-old Lloyd George, approximately 1½ acres of which were used for cane production in their first year, and 1 acre of one-year-old new seedlings in Newgates Field. Also small patches of new seedlings and odd varieties in Egham Field.)

Raspberries suffered less from the frost than some soft fruits, and yielded a little more than a half of what might have originally been expected. The fruit, however, was small.

The actual yield from the four acres of Lloyd George came to 4 tons 8 cwt. or 22 cwt. to the acre.

Whilst jam fruit prices differed little from those of the previous year, chip fruit sold well at distinctly higher prices and it was possible moreover to market a considerably larger proportion in this way. The actual quantities marketed in chips and tubs were as follows :—

"Selected" (consisting of bright, firm, better quality fruit) in 3 lb. chips, 2,900 lb. Price 6d. to 1s. a lb.
Grade 2 in 3 lb. chips, 2,700 lb. Price 4d. to 8d. a lb.
Ungraded in 3 lb. chips, 500 lb. Price 4d. to 7d. a lb.
Jam fruit in tubs, 4,000 lb. Price £24 to £27 a ton.

Including 4 cwt. from the odd pieces some 4 tons 12 cwt. of fruit were marketed, for which the gross sum of £213 or £46 a ton was obtained.

Gooseberries.—(Area under cultivation—2 acres interplanted between bush pear trees, and consisting of a variety collection of Careless, Freedom, Greengage, Gunner, Keepsake, Leader, Leveller, White Lion and Whitesmith, the bushes being from seven to fifteen years old. Also ¼ acre of four-year-old bushes. Both in Egham Field.)

In spite of a considerable drop after the frost in May, most varieties set a good crop. Careless seemed to be the least affected by the frost, while Gunner and Greengage (believed to be one and the same variety) appeared to suffer most. (*Note.*—The Careless grown at East Malling is not the Wisbech Careless, but a variety producing a round berry which becomes a white cloudy colour when ripe.)

The fruit as usual was left to ripen for dessert. Apart from Whitesmith and a small quantity that was picked green the crop amounted to some 4 tons 8 cwt. for which the sum of £145 gross was obtained, or approximately 3½d. a lb. The crop was machine graded, which was found to be considerably quicker and more accurate than grading by hand. It was also for the first time marketed under National Mark Standards, particulars of which may be of interest to growers.

Diameter.	No. Berries to 1 lb.	Package.	Grade.	lb. Marketed.	Price per lb.
Over 1⅛" ..	24-30	6 lb. chip.	Very large. Size 1.	350	4d.-8d.
1"-1⅛" ..	30-40	12 lb. chip.	Very large. Size 2.	3,600	2½d.-6d.
⅞"-1" ..	40-50	12 lb. chip.	Large. Size 3.	3,500	2d.-5d.
11/16"-⅞" ..	60-80	12 lb. chip. and ½ sieves.	Large. Size 4 or Grade 3.	1,900	2d.-4d.
Under 11/16" ..	—	½ sieves.	Smalls.	80	2d.
Mixed Grades.	—	12 lb. chips and ½ sieves.	—	350	—

Generally speaking the higher prices were those obtained by Gunner, Leader, Leveller and White Lion and the lower ones by Careless, Keepsake and Freedom.

In 1934, owing to poor prices, the greater part of the Whitesmith was left unpicked. This year it was found possible to market the entire crop, some 25 cwt., which fetched £30 or a little over 2½d. a lb.

The quality was such that it would have been possible to market practically the entire crop under the National Mark, though actually it was found more economical to market a proportion of those under ⅞ in. in diameter in half sieves. The total amount marketed under the National Mark was 9,400 lb.

Red Currants.—(Area under cultivation—about ¾ acre interplanted between apple trees and consisting of some twenty odd varieties from ten to twelve years old. Also ¾ acre of five-year-old bushes interplanted between pears, which is being used for a variety and cropping trial. Both these are in Egham Field.)

Though considerable " running off " occurred as a result of frost the red currant crop was larger than at one time seemed probable, the older bushes yielding rather over 30 cwt. and the newer plot a little over 1 ton. Gross receipts amounted to £103 or nearly 4½d. a lb., prices ranging from 2½d. to 7d. As usual the fruit was marketed in 6 lb. chips.

Black Currants.—(Area under cultivation—a variety trial comprising 1 acre of eight-year-old bushes in Egham Field, 2 acres of three-year-old Baldwin and Wellington's Triple X in Newgates Field, and ½ acre of new seedling crosses.)

As was to be expected black currants suffered severely from the frost. Baldwin, however, fared considerably better than any other variety in this respect. The total crop only amounted to some 2 tons 9 cwt., 17 cwt. of which came from the eight-year-old bushes in Egham Field and some 30 cwt. from Newgates Field. The gross amount received was approximately £150, prices ranging from 5d. to 7d. a lb. with an average of 6½d. All the fruit was marketed in 6 lb. chips.

Cherries.—(Area under cultivation—0·4 acre of twelve- to fourteen-year-old Morellos, planted at 12 by 12 feet, ½ acre of nine-year-old Morellos, ⅔ acre of eight-year-old Kentish Red and ⅓ acre of Carnation and young Morellos, all at 15 by 15 feet, in Egham Field. In addition ¼ acre of seven- and eight-year-old Morellos in Newgates Field held at the disposal of the Pathology Section for spraying trials. Also a miscellaneous collection of sweet cherries.)

The cherry crop was to all intents and purposes entirely destroyed, less than 200 lb. being marketed.

Plums.—(Area under cultivation—3 acres of thirteen-year-old and 2 acres of ten-year-old trees interplanted with cherries—both in Egham Field, 2½ acres of seven-year-old trees in Church Field, also interplanted with cherries, ½ acres of Czars and Myrobolans planted for windscreen purposes in Newgates Field, and in addition 3½ acres of approximately twenty-year-old trees in Kiln Field.)

Plums suffered a fate very similar to that of cherries, Czar alone producing any fruit and then only a small and scattered crop of some 30 cwt. These were sold in 12 lb. chips at prices ranging from 3s. to 6s. a chip.

The total plum crop amounted to 34 cwt. and the gross proceeds to £65.

Pears.—(Area under cultivation—5¾ acres in Egham and ½ acre in Church Field, four of which consist of a number of different varieties from nine to sixteen years of age. The other 2¼ acres are not yet in bearing.)

The only pear to survive the frost to any extent was Conference. Though in practically every case the centre was blackened and seedless, yet a large number of fruits developed. These were mainly small and of poor shape.

Only a small proportion, however, was destined to survive to picking time, a gale of exceptional severity being experienced on 16th-17th September, which resulted in over 75 per cent. of the crop being blown down.

The total marketable crop amounted to 155 bushels (including 80 bushels of drops); of these 138 were Conference. Total receipts amounted to £40.

Apples.—(Area under cultivation—23 acres in Great East, Egham, and Church Fields, consisting of many different varieties and varying ages ranging from five to

twenty-two years. Also a further 14 acres of approximately twenty-year-old trees in Kiln Field.)

The apple crop was negligible, amounting only to some 130 bushels in all and a gross return of £37.

1934 Crop.

The apples from the 1934 crop, which had been put into gas store and to which a brief reference was made in last year's Annual Report, were marketed between 14th March and 10th May, prices considerably higher than those ruling earlier in the season being obtained.

In all some 6,070 bushels were marketed of which approximately 4,460 were Bramleys, 1,280 Lanes and 330 Edward VII.

At the start, 14th March, "Fancy" Bramleys of 2½ in. and above fetched from 5s. 6d. to 8s. a bushel, according to size, whilst by early May the price had risen to 9s. 6d. and 12s. Some 50 bushels marketed in the middle of June fetched from 14s. to 16s. Lanes of similar quality were marketed between 29th March and 11th April at 6s. 6d. to 8s. a bushel at the start and from 8s. to 10s. at the finish. The Edward VII were marketed between 27th March and 2nd April at prices ranging from 7s. to 9s. 6d. Generally speaking Domestic standard fetched about 1s. a bushel less than the above and Cull fruit from 2s. to 3s. less.

5,360 bushels in all were marketed under the National Mark.

Gross returns from the gas stored fruit amounted to £2,750 or an average of approximately 9s. a bushel. (A few notes on the results obtained from the storing of the fruit will be found on page 213). (A.C.P. and B.L.W.)

Hops.—(Area under cultivation, 9 acres—5½ acres of Professor Salmon's Seedlings in Egham Field, 3¼ acres devoted to cultural trials in Church Field and Egham Field, ¼ acre of commercial varieties in Upper Grub. About 2 acres were not in full cropping.)

Weather conditions throughout the year were somewhat unfavourable, but most varieties carried an average crop. The cold and wet conditions in the spring and early summer retarded growth, and many bines in the cultural trials of Brewers' Favourite (OP21) and Fuggles were cut back by the severe May frost. The "spike" form of Downy Mildew was very slight and it is possible that we are now feeling the benefit of three dry seasons. Two sprayings with Bordeaux mixture were given and the cones were entirely free from disease. Aphis and flea beetle were rather troublesome in the early part of the season and two sprayings with nicotine and soap were necessary for the former and one dusting with a Derris dust for the latter. The total growth of hops amounted to nearly 6 tons, and would have been considerably greater but for the severe gale of 17th September, which ruined many of the late seedlings where they had been left exposed by the picking of the earlier varieties. The gale also did considerable damage to the wirework of the garden.

Prices obtained for the various growths were very similar to those of the previous season, ranging from £8 (OV7) to £11 per cwt. for a few Manitoba and New Mexican seedlings. Mixed growths fetched £8 10s. per cwt. which was 10s. more than that obtained in 1934. Eight pockets of L21 made £8 10s. per cwt., six pockets of Fuggles, £9 per cwt. and eight pockets of Brewers' Favourite (OP21) made £10 per cwt.

The raising of rooted sets of new varieties, mainly for distribution to growers but also for our own plantings, is an increasing item in the hop work. (F.H.B.)

Routine Spraying Programme.

The method used in 1934 and described in the Annual Report for that year (p. 26) was again adopted and proved satisfactory. The work is done much more quickly with 4 ft. lances and " double " nozzles than it used to be with 8 ft. lances and single nozzles. Although an initial, anticipated, increase in the amount of spray-fluid used occurred in the first year of change (while the men were becoming accustomed to the new technique), a further season's work has shown that this was only temporary. There are indications that the amount used on some plots has even decreased, when due allowance is made for the increment in size of the trees.

The noteworthy points in the season's programme are :

1. The winter weather was not very favourable for spraying, and the number of days on which tar-oil spraying could satisfactorily be done was very limited. Hence this spraying was not completed until later than usual.

2. A green-bud application (of lime-sulphur with lead arsenate) was made on apples for the first time as a routine measure at this Station.

3. As caterpillar was not troublesome on apples, lead arsenate was omitted from the pink-bud application on most plots. A general impression was formed from subsequent observations that there was less marginal leaf-burn than is usual after application of the *combined* spray. Lane's were sprayed at green-bud but not at pink-bud ; lime-sulphur (1-30 or 40) seems risky to use on this variety even at pink-bud.

4. On gooseberries, the usual pre-blossom spray, lime-sulphur (1-30), for American Gooseberry Mildew, was omitted on account of bad weather. The bushes were very " clean ", however, and mildew did not develop.

5. Apples were not sprayed at petal-fall (with nicotine) for Sawfly. The severe frost of 16th-17th May had so damaged the flowers that the small crop anticipated was not thought to merit the expense of spraying for Sawfly-control. This later proved to be a correct assumption.

6. Raspberries were not sprayed (with Derris and soap) for Raspberry Beetle as there was no sign of infestation.

7. The second post-blossom application (of lime-sulphur, 1-100) was omitted on most apple plots. During the third week of June, when this spray would normally have been applied, the weather suddenly changed from rather cool, wet conditions to great heat which persisted for several weeks. Spraying with lime-sulphur in these circumstances is known to be a cause of spray-damage, and the risk was not taken, especially as Scab was unlikely to flourish and there was very little fruit.

As in former years, the Research Station reference number of each of the plots sprayed is given among the details below to facilitate comparison of the sprays applied to any one series of trees etc. throughout the season.

The symbols used for the sprays are :

B.M.	Bordeaux mixture.
L.S.	Lime-sulphur.
A.	Lead arsenate paste.
N.	Nicotine.
S.S.	Soft soap.
G.	Spray gelatine.
S.	Sulphur.
Leth.	" Lethalate " Standard Wetting Preparation.

All sprays are referred to in quantity of concentrate used *per 100 gallons.*

PERIOD.	SPRAY USED.	HOSTS.	SPRAYED AGAINST.	REMARKS.
		WINTER.		
10th Jan.-5th Feb.	Standard **Tar-Distillate** (5 gals.).	Apples, Plums, Cherries, Black and Red Currants, Gooseberries.	**Aphis** and **Sucker** on Apples. **Aphis** on other hosts.	All plots, except Kiln Field, West half (see below). Pears omitted as in 1933 and 1934.
23rd Jan., 1st-5th Feb.	Standard **Tar-Distillate** (10 gals.).	Apples.	Specially for **Woolly Aphis.**	Kiln Field (West half).
		SPRING AND SUMMER.		
22nd March.	**L.S.** (3⅓ gals.).	Outdoor trained peaches.	**Leaf-curl** (*Taphrina deformans*).	At Ditton Lab., and on Plots 17 and 18.
11th April.	**L.S.** (5 gals.).	Black Currant (*"grape" stage of flower-truss*).	**Big-Bud Mite.**	Plots 35 and N2.
12th April.	**L.S.** (3⅓ gals.) + Proprietary **Derris** powder (2½ lb.).	Pears (*white-bud*).	**Scab** and **Caterpillar.**	Plot 36. Lead arsenate could not be used for caterpillar because gooseberries growing beneath pears were in flower.
	L.S. (3⅓ gals.) + **A.** (4 lb.).	Pears (*white-bud*).	**Scab** and **Caterpillar.**	Plot 20. No undercrops, so lead arsenate was used for caterpillar.
13th April.	**L.S.** (2½ gals.) +**A.** (4 lb.).	Apples (*green-bud*) and Pears (*white-bud*).	**Scab** and **Caterpillar.**	Plot C3.
13th-23rd April.	**L.S.** (2½ gals.) +**A.** (4 lb.).	Apples (*green-bud*).	**Scab** and **Caterpillar.**	Plots 3, 4, 5, 8 (cordons), 10, 11, 12, 13, 14, 16, 30, 31, 33, 34, Kiln Field (West half).
24th & 26th April.	**L.S.** (2½ gals.) +**A.** (4 lb.).	Apples (*pink-bud*).	**Scab** and **Caterpillar.**	Plots C2, C3, 3, 4.
27th & 29th April.	**L.S.** (2½ gals.) +**A.** (3 lb.).	Apples (*pink-bud*).	**Scab** and **Caterpillar.**	Kiln Field (East half). Concentration of lead arsenate reduced, as burning had been noted after the spraying of the previous week.
29th April.	**L.S.** (2½ gals.).	Apples (*pink-bud*).	**Scab.**	Plots 30, 31, 33. Caterpillar not troublesome and lead arsenate omitted, to reduce burning.
	Proprietary **Derris** powder.	Apples (*pink-bud*).	**Apple Blossom Weevil** (*Anthonomus pomorum*).	Plot C3. Weevil very troublesome on this plot. The dusting was delayed for several days on account of bad weather.
30th April-1st May.	**L.S.** (2½ gals.).	Apples (*pink-bud*).	**Scab.**	Plots 10, 12, 13, 14, 16 and Kiln Field (West half). Lane's not sprayed. Lead arsenate omitted, to reduce burning, as caterpillar not troublesome.

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
3rd May.	Proprietary **Derris** powder.	Hops.	**Flea-beetle.**	Plots C5, 26, 27.
15th & 23rd May.	**B.M.** (8 lb. bluestone, 12 lb. hyd. lime).	Pears (*petal-fall*).	**Scab.**	Plots 8 (cordons), 20. Plot 36 not sprayed because gooseberries beneath the pears had been damaged by frost, and there was thus great risk of copper injury to the soft fruit.
23rd May.	**L.S.** (1 gal.)+**G.** (1 lb.) +**N.** (6 oz.).	Plums (*post-petal-fall*).	**Red Spider** and **Aphis.**	Plot 21.
24th May.	**L.S.** (1 gal.)+**G.** (1 lb.).	Plums (*post-petal-fall*).	**Red Spider.**	Plot 29.
24th May-3rd June.	**L.S.** (1 gal.).	Apples (*petal-fall*).	**Scab** and **Red Spider.**	Plots C2, C3, C4, 2, 3, 4, 8 (cordons), 10, 12, 13, 14, 16, 30, 31, 33, 34, Kiln Field, omitting the sulphur-shy Lane's, Derby and Belle de Boskoop.
24th & 29th May.	**L.S.** (1 gal.).	Plums (*post-petal-fall*).	**Red Spider.**	Plots C4, Kiln Field (East half).
4th June.	**L.S.** (1 gal.)+ **N.** (6 oz.).	Apples, Pears and Plums(*post-petal-fall*).	**Scab, Red Spider** and **Woolly Aphis.**	Plot 2, a variety collection.
	N. (8 oz.) + **S.S.** (6 lb.).	Red Currants and Pears.	**Capsid** (*Lygus pabulinus*).	Plot 27.
18th-19th June.	**N.** (5 oz.)+ **S.S.** (5 lb.).	Hops.	**Aphis** (*Phorodon humuli*).	Plots C5, 26, 27.
	N. (5 oz.) + **S.S.** (5 lb.).	Red Currants and Pears.	**Capsid** (*L. pabulinus*).	Plot 27.
17th June.	**Flowers of S.**	Strawberries.	**Mildew** (*Sphaerotheca humuli*).	Plot N2.
20th-21st June.	**L.S.** (1 gal.) +**N.** (5 oz.).	Apples (*second post-blossom*).	**Scab, Red Spider** and **Aphis.**	Plots 5, 8 (cordons).
22nd June.	**B.M.** (8 lb. bluestone, 36 lb. hyd. lime) + proprietary **Derris** powder (2 lb.).	Walnuts.	**Bacterial Blight** (*Pseudomonas juglandis*) and **Caterpillar.**	Plot 24.
21st-27th June.	**N.** (5 oz.) + **S.S.** (5 lb.).	Hops.	**Aphis.**	Plots C5, 26, 27. Also young hops on Plot 5 and Upper Grub.
4th July.	**N.** (6 oz.) + **Leth.** (8 oz.).	Young Apples.	**Aphis.**	Plots C2, 15, 18.

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
17th July.	**B.M.** (8 lb. bluestone, 36 lb. hyd. lime).	Walnuts.	**Bacterial Blight.**	Plot 24.
22nd-24th July.	**B.M.** (10 lb. bluestone, 15 lb. hyd. lime).	Hops (*pre-burr*).	**Downy Mildew** (*Pseudoperonospora humuli*).	Plots C5, 26, 27. Also Plot 5 and Upper Grub.
1st Aug.	Proprietary **Derris** powder ($1\frac{1}{4}$ lb.) + **S.S.** (5 lb.).	Apples.	**Red Spider.**	Plots 10, 11. Mainly on sulphur-shy Lane's.
	L.S. (1 gal.) + **G.** (1 lb.).	Apples (*second post-blossom*).	**Scab** and **Red Spider.**	Plots 12, 13, 14.
3rd & 6th Aug.	Proprietary **Derris** powder ($1\frac{1}{4}$ lb.) + **S.S.** (5 lb.).	Apples.	**Red Spider.**	Plot C3. Mainly on sulphur-shy Lane's.
12th-13th Aug.	**B.M.** (10 lb. bluestone, 15 lb. hyd. lime) + **N.** (6 oz.).	Hops (*post-burr*).	**Downy Mildew** and **Aphis.**	Plots C5, 26, 27.
13th Aug.	**L.S.** (1 gal.) + **N.** (6 oz.) +**G.** (1 lb.).	Apples (*second post-blossom*).	**Scab, Red Spider** and **Aphis.**	Plot C2.
15th-19th Aug.	**N.** (8 oz.) + **S.S.** (10 lb.).	Apples.	**Woolly Aphis.**	Plot 32 (Worcesters), Kiln Field.
16th Aug.	**Flowers of S.**	Hops.	**"Red Mould"** (*Sphaerotheca humuli*).	Plots C5, 26, 27. Also Plot 5 and Upper Grub.
21st Aug.	**B.M.** (8 lb. bluestone, 36 lb. hyd. lime).	Walnuts.	**Bacterial Blight.**	Plot 24.
22nd Aug.	**Flowers of S.**	Hops.	**"Red Mould."**	Plots C5, 26, 27.
6th Sept.	**N.** (8 oz.) + **S.S.** (10 lb.).	Apple Stocks (No. XVI.).	**Woolly Aphis.**	Plot N4.
23rd Sept.	**N.** (8 oz.) + **S.S.** (10 lb.).	Apples.	**Woolly Aphis.**	Kiln Field (East half). Isolated colonies sprayed from knapsack.

(M.H.M.)

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH SUMMARIES OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

In Relation to Tree Fruits

ROOTSTOCK INVESTIGATIONS.

1. Apple Rootstocks.

The after-effect of the previous year's heavy crop was seen in the reduction of blossom upon many of the trees in the main apple rootstock trials. Whilst in the case of Lane's Prince Albert, Worcester Pearmain and Cox's Orange Pippin, it varied to some extent according to stock, on Bramley's Seedling there was an almost entire lack of blossom except on a few individual trees. However, the severe frost on the night of 16th-17th May completely wiped out the crops on all varieties and only an occasional fruit survived. This unusual occurrence must undoubtedly affect both the growth and subsequent crops. Since there was little fruit to record the opportunity was taken to examine the possibilities of using the new methods of growth recording in summer on mature trees. (R.G.H. and J.A.)

The whole of the work on the older series of apple rootstock trials has been summarized and the interrelation of such factors as annual wood growth, trunk thickening, and cropping with one another has been examined. Further, owing to the grubbing of fourteen- and sixteen-year-old Worcester Pearmain and Bramley's Seedling trees upon the whole range of rootstocks, it has been possible to obtain and analyse valuable data of both " head " and root growth and to obtain some idea of the part they have played in tree performance. A full report dealing with these findings (E91) and a practical summary (E78) have been published. (R.G.H. and J.A.)

An account of the root observations made on the trees lifted during the last two winters has been published (E80 and 81). It was found that, with some exceptions, the root-systems of the worked trees bore a general resemblance to those of the young unworked stocks. As, however, most of the exceptions were shown by both varieties, it would appear that they were the result of difference in age rather than the effect of the scion on the stock. Such as were not common to both varieties were largely a matter of amount of fibre, which was difficult to gauge by this method.

If the rootstocks are classified according to the early vigour of the scion worked on them, there is, with certain notable exceptions, a gradual increase in the number

of roots in passing from the most dwarfing to the most vigorous, but in view of these exceptions it is unwise to draw any definite conclusions. Apart from this these records appear to show no correlation between form of root-system and tree performance.

(W.A.B., F.H.B. and A.F.de W.)

Detailed records have been continued on the series of eight-year-old trees of Lane's Prince Albert on the clonal rootstocks raised at Long Ashton, compared with some of the more vigorous East Malling stocks. These trees show a wide range of vigour, and though there is no stock comparable with Jaune de Metz, No. IX, for cropping, or as vigorous as No. XII, there are one or two definitely dwarfing in character, and at least one of these gives some evidence of incompatibility. Trees on several of the rootstocks which originally induced marked vigour have blossomed exceptionally heavily and show considerable promise. These trees have not yet cropped to capacity and it is hoped to maintain as complete as possible a record thereon, until the effects of heavy cropping are seen.

The series of half-standard Newton Wonder on a selection of vigorous rootstocks have been top-worked with Laxton's Superb (see Propagation). Records have been continued on a similar series of Allington Pippin, and two other trials of half-standard Lord Derby and Grenadier. The main characteristics induced by the rootstocks in these series strikingly confirm the results already obtained for bush trees.

(R.G.H. and J.A.)

The investigation of the performance of Northern Spy as a rootstock has been intensified. This problem is one which is of particular interest to growers in the Dominions. It is being investigated from several aspects. Starting with a study of the facility with which this stock roots in the nursery, its rooting habit is being followed up by means of excavations both of young and of mature trees in the plantation. An intimate study of the behaviour of trees twelve years old, worked thereon in the plantation has been made during 1934 and 1935, and efforts have been made by inarching with vigorous rootstocks and the injection of nutrient solutions to improve this performance. (J.H.)

Lack of ground prevented the planting of a large series of trees which became available this year, and were designed to elucidate the economic side of rootstock influence in relation to planting distance. These are accordingly being planted on a grower's farm, where their performance can be observed, and a further series is being prepared for planting on the Station when ground becomes available.

(R.G.H. and J.A.)

Cordon Trials. A complex trial of Cox and Worcester single cordons on rootstocks Nos. I, II, IV, VII, IX and XII has been planted. The treatments include two distances of planting, viz. (*a*) 1 ft. 9 in. and (*b*) 3 ft. 6 in. apart in the rows, and two methods of pruning, viz. (*a*) summer, and (*b*) winter + summer pruning. The trial is planned so that two manurial or other remedial measures can be superimposed later as occasion arises. (A.B.B.)

Mechanism of Rootstock Effect. Records have been continued on the series of Lane's Prince Albert trees, stem-worked and root-worked on vegetatively raised rootstocks and upon seedling roots, which are now six years old. It is proposed to lift one set of these trees for detailed analysis during the winter 1935-6.

The study of the change in structure of root and stem of apple rootstocks Nos. IX, II, XII and seedlings worked with Lane's Prince Albert, when grown above and below ground, has been continued.

The unworked apple rootstocks planted for an anatomical examination of their structure are now two years old. The trees will be lifted and sections of the stem and root cut in 1936.

The trees of Lane's Prince Albert, Bramley's Seedling and Grenadier on Nos. IX, II and XII worked for an investigation of possible scion influence on the structure of the rootstock have made good maidens. They will be allowed to grow for at least another year before they are lifted and examined anatomically.

The series of four varieties, viz. Early Victoria, Oslin, Keswick and Manx Codling, on their own roots and worked on Malling Nos. II and XV rootstocks, having completed their twelfth season, were lifted during the winter 1934-5. Detailed records of root and branch weight were added to the already comprehensive set of records accumulated on these trees. In addition, the opportunity was taken to examine the morphological characteristics of the root-systems (see 12). (R.G.H., J.A. and A.B.B.)

The propagation by root-cuttings and layering of stocks from mature trees of recorded performance has yielded sufficient individuals for a preliminary trial and those have been budded with the variety which was worked upon the parent stock.
(R.G.H., J.A. and R.J.G.)

2. Pear Rootstocks.

The results of the trials of various quince and layered free pear stocks have been summarized and published (E77). Large differences in size and cropping of trees upon various clonal quinces and layered free stocks are shown. The prevalence of scion rooting and its economic importance are stressed.

In spite of a good show of blossom on all varieties, Conference was the only variety to bear a crop, and the fruit from these trees was mis-shapen and almost entirely seedless.

Further records of growth and blossoming, however, have been obtained. Some of the more shy-bearing varieties such as Pitmaston Duchess and Doyenne du Comice, have now been set aside for experiments designed to throw light on this failure to crop, even though they blossom profusely every year.

Summaries have been made of the occurrence of incompatibility both in the case of quince and pear stocks in the nursery and in the field. These form part of a study of the whole subject, made as a preliminary to an extension of research in this direction. (See p. 92 of this Report.)

Two series of bush pears comprising four varieties (Conference, Doyenne du Comice, Beurre Hardy and Williams's Bon Chrétien) on Quince A and C and two clonal pear stocks have been placed on the farms of grower members, to test their economic value under commercial conditions. (R.G.H. and J.A.)

3. Plum Rootstocks.

Only one variety, namely Czar, showed any resistance to the frost of 16th May, and this was the only one to yield any crop. The opportunity has been taken to analyse the records from the plum rootstock trials over the last ten years and some recommendations to growers based on them were prepared for the Imperial Fruit Show.

A further progress report, in which the cropping in particular of trees on the different rootstocks is being examined, will be published shortly.

The experience at the Station of incompatibility in Plums has been summarized in the same way as has been noted above under Pears. (See p. 82 of this Report.)

A trial has been planned and the trees have been worked, and will be planted this winter, to study the effect of a series of varieties as " stem builders " on resistance to Bacterial Dieback in trees of the susceptible variety Victoria. In addition, the trial is designed to show the comparative effect of these " stem builders ", nearly all of which are worked on Myrobolan B rootstock, on the vigour and cropping of the " top worked " variety. Methods of spraying the leaves in summer and the stems in winter will also be compared on trees pruned either in the early autumn or late spring.

In a subsidiary trial in which a series of the same " stem builders " will be included, the effect of cultural methods on the disease will be tried. (R.G.H. and J.A.)

4. Peach Rootstocks.

The trained trees of Hale's Early planted against the board fence surrounding the Ditton Laboratory failed to carry a crop. This was probably due to the severe weather experienced in the spring. Similarly trained trees of Peregrine on the brick wall of the Station's packing shed set a moderate crop. This wall has a southern aspect and is sheltered from all but southerly winds.

Six vegetatively propagated selections of common peach together with three clonal races of myrobolan plum received from California have been planted out to form a preliminary nursery trial and have been budded with Hale's Early. (R.J.G.)

5. Cherry Rootstocks—Acid Cherries.

An observation made in certain previous seasons was confirmed in 1935—that acid cherry scions (in this case Kentish Red) sometimes open their blossoms earlier when on Mahaleb stocks than on Mazzards. The difference was not more than two or three days, but was very noticeable.

There is nothing further to report at present, except in relation to bacterial die-back (see under 96).

A uniformity trial of commercial seedling Mazzards against seedlings grown from seed of various individual trees (from Pennsylvania, U.S.A.) is divided into two sections, for " high " and " low " working, and includes a " control " of layered Mazzards. The low-worked trees, now two years from the bud, are already showing clear differences, the layered stocks having given more uniform trees than any of the seedlings, but it cannot yet be said whether, or to what extent, uniformity has been increased by seed selection. The stocks for high working will be grafted in the spring of 1936.

(N.H.G.)

PROPAGATION.

6. Preparation of Experimental Material.

The routine work of testing new rootstocks for ease of propagation by vegetative means has been continued and further nursery trials have been planted.

The three-year-old apple trees composed of " stem-builders " budded at three inches above ground level on the rootstocks Nos. IX, XII and a race of seedlings and top-grafted, in March 1934, with the varieties Newton Wonder and Early Victoria have borne their first fruit. In all cases despite the 5 foot length of vigorous intermediate, the trees upon No. IX bore much more fruit than trees upon the other stocks.

The preparation of the series of plum trees having disease-resistant frameworks is complete and these trees will now be planted out in the field (see 3).

The investigations in connection with the technique of vegetative propagation have been continued in collaboration with the Physiology section. Some 250 trees of Pershore plum, some of which are unworked and others budded upon themselves and upon the rootstocks Common Mussel and Common Plum, have been prepared for layering trials, the object being to test the effect of weaker rootstocks upon the rooting propensities of the comparatively shy-rooting Pershore when it is worked upon them. (R.J.G.)

7. Nursery Technique Trials.

The nursery technique studies have been continued. A progress report (Eg. 10) was published during the year on the trials of the effect of the presence or absence of wood in the bud-shield; it was shown that there was no marked difference between trees raised by the one and by the other method. The trials are being repeated over a series of years owing to the possibility that climate may influence the results.

The use of various kinds of rubber budding-strips has been further explored and it should now be possible to outline the requirements of a reliable strip to enable the manufacturers to produce an economical strip suitable for general nursery use in this country. (R.J.G.)

8. Compatibility and Incompatibility between Stock and Scion.

The annual study of effect of environmental conditions of compatibility of certain stocks and scions has been continued. (R.J.G.)

It has now become possible to plan an intensive study of the above as determined by growth measurements of stems and leaves, root development and shoot-root ratio, compatibility in relation to fruitfulness, biochemical studies, anatomical studies and relative susceptibility to disease. (R.G.H. and W.T.C.)

9. Top Grafting and Frame-working Methods for Mature Trees.

Eighty thirteen-year-old apple trees of Newton Wonder, a variety known to be susceptible to diseases following top-grafting, have been worked with Laxton's Superb in four ways: by rind-grafting with and without the retention of large ungrafted branches, oblique-cleft grafting and frameworking by means of stub-grafting. Up to the end of the first season it is plain that of the top-grafting methods the oblique-cleft has given by far the best results in regard to growth of new scions. The frameworked trees have also made excellent growth. Towards the end of the growing season many of the trees were found to be affected by a "papery bark" canker. The incidence of the disease is being noted with a view to determining any differential susceptibility which might be due to a variation in grafting technique. Further trials will be carried out as opportunities offer.

The stub-grafting method has been extended to cherries and peaches on a small scale. The results indicate the possible uses of this method of frameworking such fruits. (R.J.G.)

ROOT DEVELOPMENT.

10. Root Growth Investigations.

A further year's information on the root growth of mature apple trees on stocks I, IX and XVI has been obtained by the weekly records of our "root observation trenches", in which the root growth is watched through glass panels fixed against the soil. As before, the position, period and rate of growth, and suberization of both main and lateral roots have been recorded.

Various improvements to the trenches have been made, including the repacking of the soil profile, which had become rather loose, in three of them. This interrupted the continuity of the records for a few weeks in the dormant period, but has been amply justified by the better results obtained subsequently. Four years' observations are now available, and although the last three years have been years of unusual drought, the records give some very interesting comparisons, especially in relation to the soil temperature and moisture records obtained concurrently. A full report is in preparation. Preparations for extending these observations to manurial and cultural problems are in progress. (W.S.R., A.B.B. and M.E.R.)

11. Soil Moisture Recorders.

The direct-reading moisture recorders developed here have given much information. Considerable interest continues to be shown in their application to many problems of soil moisture movement and plant growth. A number of meters have now been sent out to irrigated areas abroad, and various parts of England. Messrs. Gallenkamp are now making both a "commercial" type embodying a Bourdon tube gauge, and a "precision" type using a mercury manometer. A full description of the instrument with details of its construction and its performance in the laboratory and the field, has been published (E86).

The drought of July and August, 1935, was sufficient to cause the older type of meter, which has no refilling tubes, to pass the breaking point; this emphasizes (*a*) the intensity of the drought and (*b*) the necessity for this refinement on instruments intended for use over long periods.

The instruments were demonstrated at the International Soil Science Congress at Oxford, and a paper on "Soil Factors in Relation to Root Growth" was given (E87). (W.S.R.)

A progress report of further soil moisture investigations appears on p. 111 of this Report.

In collaboration with Mycology, four "controlled moisture" frames have been started containing strawberry and raspberry plants which are subjected to various conditions of drought and water excess regulated according to the soil moisture conditions shown by meters in each frame, to investigate the relation of soil moisture to certain troubles observed in these plants. (R.V.H. and W.S.R.)

12. Tree Excavations.

The grubbing of two of the stock trial plots has provided an excellent opportunity for root examination.

Detailed excavations were made of the root-systems of five trees of Early Victoria apple on its own roots and on stocks Nos. II and XV. Three of these excavations

were made by the " block " system, involving the separate excavation, washing, grading and weighing of the roots from some 1,000 blocks of soil of known position, and two by the " skeleton " system, in which only root plans and photographs are obtained. The stem : root ratio of the Early Victorias was approximately 1·7 in all cases. Differences in root distribution in the soil corresponded mainly with differences in root depth. A report is in preparation.

Three fifteen-year-old Bramley's Seedling apple trees on rootstocks Nos. I, II and IX were excavated from a grass plot on the Lower Greensand Formation. The root-systems were drawn and described, and were later reconstructed and photographed. The presence of a large scion root on the tree on No. II rootstock was of particular interest. The root-systems showed general characteristics similar to those of the same rootstocks worked with the variety Lane's Prince Albert previously excavated from an adjoining plot. A report has been published (E80). (A.B.B., M.E.R. and W.S.R.)

Data obtained from the excavation of a number of apple trees under irrigated conditions in British Columbia by a visiting member of the East Malling staff have been summarized and written up (E88). Notes on the use of a soil moisture meter in the irrigated orchard are included in the report. (W.S.R.)

SPECIAL ASPECTS.

13. Biennial Bearing.

The preliminary experiments commenced in 1930 have now been brought to a close, and the results have been written up. Regular observations on various field trials in relation to stock, pruning, manuring and other conditions will be continued. (N.H.G. and A.C.P.)

An intensive study of biennial bearing has been planned in relation to tree morphology, influence of manuring and stock, control by manipulation and chemical analysis. (R.G.H. and P.K.S.)

14. Double Working.

In regard to the earlier trials with apples there is as yet nothing further to report. The nursery trial of " stem-builder " varieties is referred to under 6.

Two of the pear varieties used as intermediates, Pitmaston Duchess and Orange Bergamotte, which gave strikingly different results with two second scion varieties in the field, are under nursery trial, on quince and layered pear stocks, with four second scion varieties. The trees are now four years old. The considerable dwarfing influence of the Orange Bergamotte intermediate is fully confirmed ; but at present the trees thus dwarfed do not seem to be more precocious in bearing than others. (N.H.G.)

15. Non-setting of Pear Blossoms.

General observations relating to trials of cross-pollination, stem ringing, spur-thinning in summer and winter, pruning and " sap transfusion " have been continued (see also Breeding 30). (N.B.B., N.H.G. and H.M.T.)

An intensive study of the above has been planned with special reference to the relation to weather conditions, flower characters, artificial aids to setting, pollen studies, pruning, ringing and manuring. (R.G.H. and D.N.S.)

PRUNING.

16. Apples.

Further progress has been made in summarizing the first sixteen years' records from the original Pruning Plot. It is clear that even to the end of the period varieties differed in their response to the various treatments. Certain principles, however, remain applicable to all varieties, and will probably prove to be so in all conditions. (N.H.G.)

17. Pears.

The older series of pear varieties upon quince which have received differential pruning treatments for the past ten years have now reached a stage when length of spurring has little, if any, effect upon the quantity of blossom produced. At this stage there is little difference in cropping between the various treatments, although in some cases the accumulated total crop is higher on the regulated and lighter pruned series.

A manurial trial has been superimposed upon this series of trees (see 22).

On the younger trial, the effect of hard and light leader tipping, combined with varying numbers of leaders has already shown big differences in amount of new wood growth and on some varieties a difference in number of blossoms.

The experiment on the effect of three different methods of pruning and cropping of nine varieties of pear planted as single oblique cordons is being continued. Owing to the late frost no crop was picked. (J.A.)

18. Plums.

A trial for the study of the relation between time of pruning and the incidence of Bacterial Canker has been planned (see 3).

19. Cherries.

Four years' growth and cropping following the dehorning of alternate trees of Morello have yielded certain definite results. These will now be further checked by the dehorning of the remaining trees. (N.H.G.)

THINNING.

20. Apples.

The experiments on three dessert varieties are now being written up. It is possible that they will be continued in a modified form. (A.C.P.)

21. Plums.

There was no fruit on which to continue trials this season. (A.C.P.)

MANURING.

22. Apples.

The main result shown in the trial of nitrogen, potash and phosphate on young trees of Cox's Orange Pippin and Beauty of Bath was again the marked effect of potash

and rootstock on growth and foliage. There was an indication that those trees which have received no nitrogen were beginning to show an effect in rather lighter green foliage. The trees were planted as two-year-olds in the autumn of 1930.

The experiments in the restoration of unmanured apple trees to good health and in the combined use of grassing and manuring to obtain a suitable balance in the tree, have been modified according to the state of the trees. It may be recalled that of the Bramley's Seedling which had been given different treatments, those which had received no nitrogen were beginning to show signs of deficiency. Nitrogen has been withheld to obtain further data. As four years' results had been obtained on the effect of potash, a dressing has been given to those rows which had previously received none and the opportunity has been taken to compare the effect of two dressings, 4 and 6 cwt. per acre.

The treatment of the Worcester Pearmains receiving nitro-chalk through grass was continued for a third year. Those that had 15 cwt. per acre in the first year were again given nothing, while the others have had their annual dressing of 5 cwt. Unfortunately owing to a lack of crop it was not possible to determine whether there was a further carry-over of the heavy dressing.

On the plot of Bramley's Seedling under grass, the comparison of no nitrogenous manuring with a dressing of 5 cwt. of nitro-chalk per acre had given striking results in two years and as the unmanured trees were beginning to suffer badly from nitrogen starvation they were given 10 cwt. per acre in the year under review. As a result there was in the summer little visual difference between the foliage of the two sets of trees.

In the preliminary experiment on time of application of nitrogen, trees receiving sulphate of ammonia at different periods of the year have begun to show differences in wood growth. Differences in severity of leaf scorch had been observed previously. It is hoped to carry out a more comprehensive experiment on time of application of nitrogen on a plot of Cox's Orange Pippin and Beauty of Bath when they have come into bearing, and records have been taken on the young trees in order that their full history shall be obtained.

The planning of a pruning trial on cordon apples which has been begun this year allows for two manurial or other remedial treatments to be given in later years in conjunction with the pruning. (W.A.B.)

23. Pears.

A preliminary field experiment on the potash and nitrogen requirements of pears was begun on a rootstock and pruning plot. The treatments consist of (*a*) shoddy + steamed bone flour, (*b*) *a* + sulphate of potash, (*c*) *b* + sulphate of ammonia in spring. It is hoped that this experiment will yield data which should be valuable in planning a more comprehensive pear experiment in the near future. (W.A.B.)

24. Plums.

A series including eight varieties of Damson on Myrobolan B has been planted. These will later receive different quantities of nitrogen with a view to studying its effect on biennial bearing and delayed fruit ripening.

Three acres of four-year-old Giant Prune on Myrobolan B have recently been acquired and it is proposed to develop some preliminary manurial trials upon this material. (W.A.B.)

The pot culture experiment with the variety Victoria has been continued in collaboration with the Pathology Section (see under 74). (F.H.B. and H.W.)

IRRIGATION.

25. Effect of Artificial Irrigation.

Data obtained from small irrigation trial of apples are being prepared for report. Soil moisture records have been kept on the irrigated and control plots. (W.S.R.)

VARIETIES AND CLASSIFICATION.

26 and 27. Apples and Pears.

Observations on cordon trees of newer introductions of commercial or breeding value have been continued. The records of time of blossoming of a considerable range of apple, pear and small fruit varieties have been published (E82).

(A.B.B. and H.C.C.)

28. Cherries.

In spite of a still more serious attack of bacterial die-back in 1935, certain varieties are still outstanding in their resistance to this disease. One of these has now been chosen, and buds of it inserted in stocks, for "frameworking" trees of the more susceptible varieties. (N.H.G.)

SPRAYING AND TREE PERFORMANCE.

29. Observations in collaboration with the Insecticides and Fungicides Section.

These have been continued.

BREEDING.

30. Apple Rootstocks.

Further progress has been made in breeding new varieties of apple rootstocks immune from Woolly Aphis, undertaken by this Station in collaboration with the John Innes Horticultural Institution. A paper is in course of preparation. 574 seedlings of proved immunity under East Malling conditions are now undergoing propagation tests.

Detailed records have been continued on the immune seedlings, Merton 778, 779, 789 and 793, worked with Lane's Prince Albert. A progress report has been published (E83). It is shown that all were definitely more vigorous in their influence on the scion variety than Malling No. IX, and less productive of both flowers and fruit during their earliest years. The results suggest that two of the seedlings, 779 and 793, were less vigorous in their influence over the scion variety than either 778 and 789. A number of trees worked on the two selections 779 and 789 were excavated during autumn 1935, and some interesting differences in their root-systems were found.

A paper dealing with the variations in leaf shape and petiole length of seedlings from crosses between Malling No. IX and a wide range of other Paradise rootstocks has been published (E79). Statistical analysis shows that the variation in these characters between the seedlings of the families was only slightly greater than that between leaves obtained from clonal races of the parent rootstocks. The results appeared to indicate that these characters are controlled by a polysomic genetic mechanism.

Records have been continued upon a series of nine selections from a family of VIII × IX worked with Lane's Prince Albert in 1930. Interesting differences in vigour are already appearing.

About 180 seedlings from two families IV × IX, and IX × VI, worked with Lane's Prince Albert in 1934, are being recorded in detail with the object of obtaining information on the inheritance of rootstock influence. A number of other seedlings are being tested as rootstocks. (H.M.T.)

31. Plum Rootstocks.

Several families of seedlings were raised during 1935 from crosses between plum rootstocks, with the object of raising new rootstocks combining ease of propagation and compatibility. Other families raised in 1933 have been planted out for propagation tests.

Records have been continued on a trial of 160 seedlings of *Prunus divaricata* collected from the Caucasus and Asia Minor, worked with Czar plum in 1932. Several instances of delayed incompatibility have been encountered and the trees are showing interesting differences in vigour and precocity. A number of seedling plums from other foreign sources are also under observation. (H.M.T.)

32. Testing Hardiness of Imported Wildings.

A series of apple, pear and quince seedlings, raised from seed collected in the Caucasus and Turkestan, have been under trial during two seasons to test the readiness with which they can be multiplied by vegetative propagation. It is thought that these seedlings may possess qualities which will make them valuable as new rootstocks. A trial has been arranged to test whether any of the 300 quince seedlings will prove compatible with certain pear varieties which are incompatible with the varieties of quince rootstock at present in common use. Each seedling will be worked with at least two incompatible varieties. In order to economize ground, the stocks will be budded on the stools. (H.M.T.)

33, 34 and 35. Scion Varieties of Apples and Pears, and Shortening the Juvenile Period.

A large number of crosses were made during 1935, between Northern Spy and several good quality dessert varieties, with the object of producing new varieties of apples combining immunity from attack by Woolly Aphis with other desirable characters. Seedlings raised during the previous year were tested for immunity. Several crosses designed to provide information on the inheritance of fruit colour in the apple were made, and work has been continued on the production of seedlings of high fruit quality and extended season.

A preliminary trial of seedling apples worked on rootstocks Nos. IX and XII, and growing on their own roots, planted with the object of testing whether a dwarfing

and precocious rootstock can hasten the blossoming of seedling apples has again furnished evidence that this is the case. A number of trees, all of them upon No. IX, blossomed, but owing to the severe frost, no fruit was obtained. Material for a larger trial is in course of preparation. Some blossom was obtained upon scions of seedling apples worked upon a twenty-one-year-old tree of Lane's Prince Albert in 1932, showing that this method may prove effectual in shortening the juvenile period. Root restriction by growing seedlings in pots, whether out of doors or under glass, has not, so far, proved successful.

Many crosses were made between pear varieties in an attempt to obtain seedlings of high quality and extended season.

A large number of pollinations were made between Doyenne du Comice, Glou Morceau and Conference in an attempt to elucidate the causes of the persistent failure of the former variety to set fruits. Owing to the severe spring frosts no success was obtained (see under 15). (H.M.T.)

MARKET QUALITIES.

36. Market Problems.

Investigations are being continued with regard to the different methods for the marketing of fruits with special reference to the influence of such factors as variety, stock, season, thinning, manuring and cultural operations and their effect on market value. (A.C.P. and B.L.W.)

SOIL TYPES AND PLANT PERFORMANCE.

37A. Survey on the Hastings Beds.

This report is nearing completion. During the course of the Lower Greensand and Hastings Beds' surveys, it was found difficult to compare tree growth on the various soil series as a result of the variation in such factors as rootstock and manurial and cultural treatment. To give a greater measure of the potentialities of some of these series, small plots will be planted in the winter of 1935-6 if suitable sites can be found. The trees will be of two varieties on representative rootstocks. There will be two manurial treatments and if possible trees for root excavation will be included.

(W.A.B., N.B.B. and W.S.R.)

37B. Survey of Frost Damage.

In view of the severe and patchy nature of damage resulting from the frosts of mid-May it was thought that a unique opportunity for investigation was provided.

Accordingly a questionnaire was sent to all Members of the Research Station, while various members of the Pomology Staff, assisted by a voluntary worker, made a survey of the damage in various parts of Kent.

The results so obtained were given in a paper read at a Conference held at the Research Station. Another paper on the preliminary results of a survey of the literature was also read. Both papers appeared in the Report of the Conference (E92, E93).

The experience gained up to this point made possible a more accurate investigation of damage on some Essex farms.

The results of these various investigations showed the value of height relative to that of the surrounding land, the good effect of nearness to large rivers or the sea, the lack of evidence with regard to manuring and cultivation, the good and bad effects of windbreaks, resulting in apparently contradictory results, and the variation in susceptibility to damage among varieties. It is thought that much that was at first inexplicable can be explained by the existence of a light north wind during the night of the most severe frost. (W.A.B. and C.F.C.)

Special Crops

WALNUTS.

38. Propagation of Varieties, Storage and Diseases.

Propagation. At present seedling rootstocks of *Juglans regia* and *J. nigra* have to be relied on, though it is not yet known what influence, if any, seedlings of these species may have on the subsequent behaviour of the tree. Meanwhile a promising beginning has been made by applying layering methods in order to obtain vegetatively raised clonal root-systems. Certain hybrids of *J. regia* and *J. nigra* crossed with *J. californica* —known respectively as Paradox and Royal—root fairly readily and have now been successfully grafted with some of the selected varieties. The results appear to be as promising as grafting upon seedling rootstocks and the progeny should be more uniform.

Whilst there seems little further improvement necessary in the methods of indoor grafting which have been successfully evolved at East Malling to meet English conditions, methods of outdoor propagation—which should cheapen the process—are still being sought. Grafting in the open has proved very precarious because the walnut is very slow to form callus tissue and the scions dry out before the union has been obtained. Experiments in outdoor budding have been continued, and promise much greater success. Buds of the previous season's wood are inserted in May and June and start into growth the same year. If this method continues to be as promising as the early experiments suggest, it could be used on seedling trees up to twenty-five years old so as to " over-work " them to a named variety.

Rootstock Trial. The small grove of Franquette and Mayette on seedling *regia*, *nigra* and *californica* stocks is being kept under observation, and a more complete series of trees on different rootstocks is being raised for a more extended trial.

Distribution of Varieties. Now that the simple glasshouse method of propagation has been demonstrated to nurserymen, the main stock of the twelve selected varieties has been handed over to four firms as a nucleus for further propagation. Young trees should be available to growers from these sources in the near future.

Contact is being maintained with the sets of experimental trees placed in different parts of the country to test their suitability under various conditions.

The demand for trees of named varieties is now far exceeding the supply at East Malling, since resources now only permit of the raising of very few for experimental purposes.

Pruning and Form of Tree. Pending the discovery of any dwarfing rootstock, an experiment in shaping and pruning walnuts as bush trees for small gardens has been

undertaken. Preliminary results suggest that summer pinching may both restrict growth and encourage early fruitfulness.

Control of Diseases. The spraying with Bordeaux Mixture (8 : 8 : 100) of trees suffering with Bacterial Blight, which has already been described, has been applied successfully to control the disease.

The sterilization of the rootstocks before grafting with a 1 per cent. solution of formalin in order to prevent graft disease caused by a fungus named *Chalaropsis thielavioides*, already fully described (E85), has again been undertaken with complete success (see 80B). A résumé of the present position has been published (E63).

(A.W.W. and J.B.M.)

HOPS.

39. Testing and Distribution of New Seedlings.

Fifty-two varieties, including five commercial varieties badly infected with " mosaic " disease, have been grubbed. Thirty-one new seedlings have been planted out for preliminary trial.

The crops from 178 varieties were dried separately for cropping records. This figure is somewhat smaller than in recent years owing to the severe September gale which rendered it impossible to take crop records of over forty seedlings. Samples of dried hops for analysis were taken from seventy-eight varieties. The crop from fourteen seedlings was pressed separately in part pockets for use in brewing trials.

The analysis of the 1934 crop once again proved " Brewers' Gold " (C9a) to be the richest hop in the world. Amongst the early hops X35 remains the best new variety with a preservative value of 9·48 per cent.

In the mid-season hops R1/9 was at the top with the remarkable preservative value of 11·81 per cent. and is now being submitted to brewing tests. Among the late varieties Q43, a hop of similar parentage to " Brewers' Gold " (C9a) was analysed for the first time and was amongst the three richest hops. As a growers' hop Q43 is superior to " Brewers' Gold " in possessing larger cones ; it has also proved satisfactory in brewing trials.

Other late varieties with good analyses are OQ22 and OI47, the latter having been selected for use in a large scale cultural trial as soon as material is available.

This work has been carried out in collaboration with Prof. E. S. Salmon, the raiser of the new varieties, who has published a report, and Mr. A. H. Burgess of the South-Eastern Agricultural College who has undertaken the analyses.

Distribution of New Varieties. " Brewers' Favourite " (OP21) has so far proved satisfactory on the several farms where it is now being grown. This variety is still being propagated at East Malling and over 4,000 sets are being distributed in 1935-6. The seedling OO63 is also being raised in quantity and it is hoped to introduce this variety to growers in the autumn of 1936. (F.H.B. and J.A.)

40. Cultural Trials.

The trial of various distances of planting and the number of bines per string on the seedling L21 has been continued. Distance of planting still continues to have a more marked effect on the yield than the number of bines per string. The experimental plot of " Brewers' Favourite " (OP21) again gave results in favour of close planting,

but the increase over wide planting was considerably less than in 1934. The differential pulling treatments were initiated this year, but they failed to affect the cropping. The two treatments, however, showed marked difference in their susceptibility to damage by the May frost.

The trial of three strains of Fuggles had the crop recorded for the first time, and there are indications that there may be differences between the strains. One strain gave a significantly heavier crop than the others and also suffered less from frost damage to the young bine. The hard and light cutting treatments had no effect on the cropping, possibly due to frost damage. In the early spring the lightly cut plots were considerably more forward than the hard cut plots ; the former suffered so much more severely from the May frost that later in the season the plots were indistinguishable. Owing to shortage of bine in the spring it was not possible to commence the trial of different numbers of bines per string with the seedling OV7.

Half-acre plots of the seedlings OO63 and P13 will be utilized for further cutting, pulling and distance of planting trials. (F.H.B. and J.A.)

In Relation to Small Fruit

CLASSIFICATION, NOMENCLATURE AND VARIETIES.

41. Currants.

The trials of the main varieties of Black Currant and the East Malling seedlings, Wellington's Single X, Double X, and Triple X, planted in February, 1928, have been grubbed and a report on the cropping to date is being prepared. Half of the bushes in the two-year-old variety and distance of planting trial containing representatives of these groups were again cut down to test the effect of this second pruning on the eventual size and crop of the bushes. The new crops of the four-year-old Baldwin and Triple X planted at suitable distances were considerably reduced by frost, but the earlier flowering Baldwin was least affected and gave in consequence a heavier yield per bush.

In Red Currants some reduction in crop, due to frost damage, was observed upon all the fourteen varieties in the trial but quite average yields were harvested. During the severe gales in June, certain varieties were badly damaged by the blowing out of the young leading growths, the most damage being upon Fays, Versailles, Wilson's Longbunch and Prince Albert. Those least affected were Raby Castle, Houghton Castle, Scotch and La Constante. It is proposed to carry out summer and winter treatments upon the one-year growths on these bushes and on a new series of young bushes in order to overcome this serious defect. (R.G.H. and J.A.)

42. Raspberries.

See under IX.

43. Loganberries, Blackberries and Dewberries.

See under XI.

44. Strawberries.

See under X.

BREEDING.

45. Black Currants.

Observations have been continued on a series of Black Currant seedlings, raised in 1930 by inter-crossing the main varieties. Owing to the severe spring frosts little fruit was obtained but several promising seedlings have been observed. A further season's study of these seedlings supports the view that many of their characters are inherited in a simple manner. Seven selections from an earlier trial, chosen for their heavy cropping and other qualities, are being propagated in quantity for further trial. A number of seedlings of hybrids between the Black Currant, *Ribes longeracemosum* and the Gooseberry are being kept under observation. They have again proved completely sterile.

Seedlings of Baldwin and Boskoop Giant obtained from seeds, ovules and pollen treated with X-rays at the John Innes Horticultural Institution, have been examined. Little evidence that this treatment has induced mutations has, so far, been found.

(H.M.T.)

46. Red Currants.

This work is temporarily in abeyance.

47. Raspberries.

See under IX.

48. Strawberries.

See under X.

PROPAGATION.

49. Currants.

A clonal disease-free nucleus is being maintained.

50. Raspberries.

See under IX.

51. Gooseberries.

Clonal dessert varieties are being maintained.

52. Strawberries.

See under X.

53. Loganberries and Blackberries.

See under XI.

PLANTING, TRAINING, PRUNING, THINNING.

54. Currants.

Suitable distances and pruning treatments are being tested (see 41 above). (R.G.H. and J.A.)

55. Raspberries.

See under IX.

56. Gooseberries.

Fruit thinning trials are continued as opportunity permits. (A.C.P.)

57. Strawberries.

See under X.

58. Loganberries and Blackberries.

See under XI.

MANURING.

59. Raspberries.

See under IX.

60. Strawberries.

See under X.

PUBLICATIONS DURING THE YEAR.

Tydeman, H. M. "A Study of the Variations in Leaf Shape and Petiole Length in Seedlings of 'Paradise' Apples." Journ. Pom. and Hort. Sci. (March, 1935). **13,** 32-8. (E79.)

Summary.

Measurements of the breadth of the leaves and of the length of the leaf petioles of 525 seedlings from crosses between varieties of the "Paradise" apple rootstocks are summarized and discussed.

Hamond, J. B. "The Future of Walnut Propagation in England." Horticultural Advertiser (January 24th, 1934), No. 2,649, 14, and E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 239-41. (E63.)

Beakbane, A. B., and De Wet, A. F. "The Root-systems of some Bramley's Seedling Apple Trees." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 87-9. (E80.)

Bane, W. A., Beard, F. H., and De Wet, A. F. "A Comparison of the Root-systems of Mature Trees of Bramley's Seedling and Worcester Pearmain on Various Rootstocks." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 90-9. (E81.)

Beakbane, A. B., Chapelow, H. C., and Grubb, N. H. "Periods of Blossoming of Some Tree and Soft Fruit Varieties at East Malling." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 100-14. (E82.)

Tydeman, H. M. "Apple Rootstocks Immune from Woolly Aphis. A Progress Report on Trials with New Varieties." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 115-22. (E83.)

Hatton, R. G. "East Malling's Experiences with Apple Rootstocks." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 223-8. (E78.)

Hatton, R. G. "Rootstocks for Pears." Report of the Royal Hort. Soc. Conference on Apples and Pears, Varieties and Cultivation in 1934 (1935), 154-66, and E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 75-86. (E77.)

Harris, R. V., Massee, A. M., Rogers, W. S., and Lauder-Thomson, I. "Present Day Strawberry Problems at East Malling." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 229-31. (Esf. 27.)

Grubb, N. H. "Raspberry Breeding at East Malling, 1922-34." Journ. Pom. and Hort. Sci. (June, 1935). **13,** 108-30. (Esf. 28.)

Summary.

An account is here given of observations made over a period of thirteen years on thirty-five families of raspberry seedlings, produced by selfing and crossing named varieties and seedlings.

The objects of the work, the characters of a good commercial raspberry, varieties at present in cultivation from which the breeder might obtain these characters, and a score card for judging the commercial value of the fruit, are in turn described. The early growth and fruit bearing of raspberry seedlings are discussed in relation to juvenility.

An attempt is made to show the comparative value as parents, both when selfed and when crossed amongst themselves, of different named varieties and seedlings. The most valuable commercial varieties do not necessarily produce, when selfed, the largest proportion of promising seedlings ; nor do those varieties which, when selfed, give the largest proportion of promising seedlings, always give equally promising results in crossing.

The most hopeful line of work so far found, and applicable probably outside the limits of raspberry breeding, is the crossing of promising seedlings belonging to different families, and particularly to different selfed families. It is important that selfed seedlings chosen for crossing should not have the faults of their parents in a degree equal to that of the parents.

Though the work was not primarily designed to give results of genetic interest, the bearing of the available records on the published results of Crane and Lawrence in the inheritance of colour, sex and hairiness, is discussed. Some additional characters of mainly genetic interest are described.

Garner, R. J. "Studies in Nursery Technique. Shield-Budding—The Removal of the Wood. A Progress Report." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 123-6. (Eg. 10.)

ROGERS, W. S. "A Soil Moisture Meter depending on the 'Capillary Pull' of the Soil. With illustrations of its use in Fallow Land, Grass Orchard, and Irrigated Orchards." Journ. of Agric. Sci. (July, 1935). **25,** 326-43. (E86.)

SUMMARY.

1. A soil moisture meter which gives direct and continuous measurement of the soil moisture content is described. The instrument consists of a special porous pot filled with water, connected by a tube to a mercury manometer. The pot is buried in the soil, whose capillary pull causes the mercury to rise. The height to which the mercury rises depends on the amount of moisture in the soil, and also on the size of soil particles and the degree of compactness of the soil. (The last two factors remain constant for an instrument in one position.)

2. To read actual moisture percentage each instrument has to be calibrated for the soil in which it is placed. Once this is done, all sampling and weighing is eliminated.

3. The range of the instrument in its present form runs from saturation to about 1·5 per cent. moisture (calculated on dry weight) in sand, to about 8 per cent. in light loam, and to about 21 per cent. on heavy clay.

4. Within this range increases and decreases of soil moisture are recorded rapidly and consistently.

5. This type of moisture meter is prevented from giving absolutely precise readings of the soil moisture content owing to the fact that the moisture : pressure-deficiency curve tends to form a hysteresis loop, i.e. does not follow exactly the same course for rising moisture as for falling moisture. The degree of accuracy appears to be sufficient for many purposes, however, for the variability is usually within 10 per cent.

6. Special devices are used to prevent freezing and enable the instrument to give a record over long periods without attention in the field.

7. Examples of the working of this moisture meter in the laboratory and in the field are given. Instruments placed at different depths in clean cultivated land and in grass orchards have shown the contrast between loss of water by evaporation, which hardly affects the soil moisture at 30 in. and loss by root absorption which draws on the deeper layers as well as the surface layers of the soil.

8. In an irrigated orchard the meters have satisfactorily shown the penetration of irrigation water and the drying out of the soil at various depths.

CORNFORD, C. E. "A Summary of the Literature on Frost Damage in the Orchard and its Control." Fruit Grower (September, 1935). **80,** 457-8. (E92.)

SUMMARY.

The variation in frost hardiness of flowers, young fruits, roots and branches is outlined. Mention is made of the relation of cold weather to bees and pollination.

Some facts are given about the problem of how freezing kills plant tissue.

Attention is drawn to the difference between a blizzard and a radiation frost, and a normal sequence of events during the latter is described.

Mention is made of the usefulness of a knowledge of water vapour, the dew-point, clouds and rain in relation to the prediction of frost.

Evidence is mentioned which disproves the statements that sunlight is injurious to frozen young parts of fruit trees, and that spraying plants with ice-cold water thaws them slowly. The lowest temperature during the day is often reached after sunrise.

A short history of frost fighting is given, and mention made of modern methods of controlling frost damage, which are mostly impracticable.

The best method appears to be orchard heating which is briefly described and the question of its cost is raised.

Windbreaks, which have been little studied, are neither universally beneficial nor injurious from the point of view of protecting orchards from frost damage.

BANE, W. A. " Report on our East Malling Frost Damage Survey." Fruit Grower (September, 1935). **80,** 458-60. (E93.)

SUMMARY.

This is a paper read at the Conference at the East Malling Research Station on Hard Fruit Day, at which the severe damage resulting from the frosts of mid-May was discussed.

It gives the results of a detailed survey made by members of the Pomological Staff on as many farms as possible in certain parts of Kent, supplemented with information obtained by means of a questionnaire to Members.

The most important conclusions refer to the value of height relative to that of the surrounding land, the good effect of nearness to large rivers or the sea, the lack of evidence with regard to manuring and cultivation, the good and bad effects of windbreaks, resulting in apparently contradictory results, and the variation in susceptibility to damage among varieties.

The results support the hypothesis that there was a light northerly wind during the night of 16th-17th May, and that plantations into which it blew were less damaged by frost than those in which the cold air collected and remained stagnant.

The paper also refers to the results of orchard heating carried out on a number of farms.

ROGERS, W. S. " Soil Factors in Relation to Root Growth." Trans. 3rd Inter. Congress Soil Sci. (September, 1935). **1,** 249-53. (E87.)

SUMMARY.

The root growth of mature apple trees on loam, sand and clay is described and compared. The relation between root and stem growth and various soil factors, as shown by excavations and in root observation trenches, is discussed. Various limiting factors including soil hardness, fertility, aeration and moisture are noted.

The importance of further study of root growth in relation to soil factors is emphasized.

ROGERS, W. S., and VYVYAN, M. C. " A Device for Serial Recording and Automatic Counting in Categories." Journ. Pom. and Hort. Sci. (November, 1935). **13,** 220-2. (E89.)

SUMMARY.

A recording apparatus consisting of a portable typewriter with reset counters attached to certain keys is described. This apparatus records observations represented by various letters in serial order and automatically counts the number of cases in different categories. In the case of growth census records or plant-to-plant surveys of plots a series of records of the same plants can be made on one sheet, showing the progress of each plant. The apparatus can be used indoors or in the field.

ROGERS, W. S. " Root Studies VI. Apple Roots under Irrigated Conditions, with Notes on Use of a Soil Moisture Meter." Journ. Pom. and Hort. Sci. (October, 1935). **13,** 190-201. (E88.)

SUMMARY.

1. An eight-year-old McIntosh apple on a seedling rootstock was excavated in detail from an irrigated orchard at Summerland, B.C. The branch height was 5·4 m., the mean branch spread 3·55 m., and the mean root spread 8 m.

2. The roots were mainly thin and wiry. Most of them were between 30 and 50 cm. deep. A few turned downwards and reached a maximum depth of 146 cm. There was no deep tap root. The relative concentration of roots between 30 and 50 cm. may be the combined result of the surface irrigations and the cover crop.

3. The ratio of branch weight to root weight was 1·99. The relatively high amount of branch to root on this sandy soil is probably largely due to the artificial irrigation, combined with the other climatic factors.

4. A hundred and seventy-five three-year-old apple trees of fourteen varieties, all on Canada Baldwin piece roots, were excavated at the Dominion Experimental Station, Summerland, British Columbia. Great variation was found between the root-systems, even when grafted with the same variety. None of the varieties exercised a readily visible qualitative effect on the seedling roots.

5. Some comparable trees on Malling clonal stocks had root-systems very different from the seedling root-systems.

6. In some varieties 100 per cent. of the trees on seedling roots had begun to form scion roots. The amount of scion root was very small at this age, however. Nine out of fourteen varieties showed some scion rooting.

7. Both roots and branches showed remarkable vigour under these irrigated conditions. Roots reached a length of 5 ft. and a depth of 3 ft. 6 in. in two years after planting.

8. A twelve-year-old Winesap apple tree suffering from " Collar Rot " was excavated. It was found that most of the main roots were dead at the crown. Some were dead throughout, and some alive below the crown.

9. A continuous-reading soil moisture meter for use in the field is described. Examples are given of its working. The capillary pull corresponding to optimum growth conditions is discussed.

HAMOND, J. B. " Recent Developments in Walnut Growing in England." Journ. of the R.H.S. (November, 1935). **60,** 501-7. (E90.)

SUMMARY.

An outline of the walnut investigations at this Station is given in explanation of an exhibit arranged under the auspices of the Royal Horticultural Society. The following points are dealt with :

1. The importance of vegetative propagation as a means of improving the quality of English walnuts. In addition to the usual method of propagation, a new budding technique is described. Mention is also made of the production of bush walnut trees for growing in a limited space.

2. Data concerning the number of grafted walnut trees distributed from this Station during the last four years.

3. Successful methods of bleaching, curing and storing walnuts during the winter.

4. The symptoms and control of the two principal diseases to which walnut trees are subject in this country.

5. Notes on walnut culture.

HATTON, R. G. " Apple Rootstock Studies, Effect of Layered Stocks upon the Vigour and Cropping of Certain Scions." Journ. Pom. and Hort. Sci. (December, 1935). **13,** 293-350. (E91.)

SUMMARY.

1. Progress reports of 1920, 1927 and 1929 are summarized.

2. The origin, propagation and method of working the rootstocks and of planning, planting, pruning and treating the young trees uniformly are described. Any possible effects of subsequent cultural and manurial treatments upon the maturing plantation are discussed.

3. Scion rooting of Bramley's Seedling on Nos. VIII, IX, and, to a lesser extent, on Nos. II and VII is recorded.

4. The effects of rootstock upon tree growth as manifested in total wood measurements, weights of sample prunings, thickness of trunk, height and spread of branches and total weight of trees and their inter-relationship are compared, and their relative value discussed.

5. Changes in the relative order of vigour as expressed by total wood growth are reported and the advisability of adhering to a method of grouping rootstocks according to vigour is discussed.

6. Measurement of cross section of stem is used to demonstrate the fact that the vigour of different scion varieties on the same rootstock is affected to a different degree, and that the terms " dwarfing " and " vigorous " are therefore relative only.

7. Whilst the majority of rootstocks—Nos. VIII, IX, IV, VII, X, XII, XVI—appear to exert relatively the same influence upon all four scion varieties, definite scion partialities are now evident upon rootstocks Nos. I, II, V and VI, as shown by vigour and to some extent by cropping.

8. Influence of rootstock on habit of growth of the scion is illustrated.

9. Total weights of branches, trunk and part roots of 246 fourteen- and sixteen-year-old trees are given. Scions on very vigorous rootstocks are found to be four and five times as heavy as those on very dwarfing ones. The ratio of branches to trunk varies upon different stocks. It is shown that different rootstocks modify the ratio of tree weight to cross section of trunk for a single scion variety.

10. Effect of rootstock upon earliness of coming into bearing is emphasized by the outstanding behaviour of trees on Nos. IX and IV, though the former have now been outstripped as the trees on the best of the vigorous (Nos. I and II) and very vigorous stocks (Nos. OF5, XVI and Crab A) reach " maturity ".

11. An attempt to trace the effect of early cropping upon ultimate vigour is made by a comparison of additional wood growth, stem increment and weight of crop from year to year.

12. Total crop per tree at any one period is shown to obscure the real cropping history of particular combinations, though at the end of sixteen years trees on some rootstocks have borne twice to three times the weight of fruit harvested from others. Scion preferences are evident. A fair comparison, however, is found possible between the average total crops for the four varieties upon certain rootstocks giving trees of approximately the same size and maturity. Whilst trees on No. I appear second on the

list, those on No. VI are fifth. Again, those on No. II (Doucin) are fourth, those on No. V (Improved Doucin) tenth and last.

13. Total crop in relation to total branch and stem weight gives a most striking demonstration of rootstock influence. On No. IX rootstock trees of one variety have produced 7·5 times their own weight in fruit, whilst on No. XII tree and fruit weight are approximately equal at the end of fourteen years. Ratio of crop to tree weight is invariably low for trees on No. V rootstock.

14. Instances are given where rootstock influence upon fruit size outweighs the number of fruits borne in proportion to tree size.

15. The evidence of rootstock effect on leaf areas, growth types, fruit bud formation and position, percentage of blossom setting, time of blossoming, fruit colour, storage quality and resistance to rots, chemical composition of fruit, disease resistance and susceptibility, and physiological troubles is briefly summarized.

16. Various attempts to elucidate the causes and mechanism of rootstock effect are reviewed.

BEAKBANE, A. B. " Blackberries and Loganberries." Report of the R.H.S. Conference on Cherries and Soft Fruits, Varieties and Cultivation in 1935. 129-32. (Esf. 29.)

SUMMARY.

A number of loganberry variants and rogue varieties present in a collection of plants received at East Malling as loganberries are described.

The presence of blackberry variants in the varieties Himalaya and Parsley Leaved Berry is noted.

A succession of blackberries and loganberries for garden purposes is given.

SALMON, E. S. " Eighteenth Report on the Trial of New Varieties of Hops, 1934." East Malling Res. Sta. (August, 1935). (B26.)

SUMMARY.

1. Of the 238 varieties (new and commercial) tested, eight new varieties cropped at the rate of over 30 cwt., forty other new varieties at 25 cwt. or over, and eighty new varieties at from 20 to 24¾ cwt. to the acre.

2. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 77 to 139.

3. In all the classes (early, mid-season and late varieties) certain new varieties proved on analysis to be richer in preservative qualities than any of the commercial varieties.

4. The new variety C9a (" Brewers' Gold ") was richer in preservative qualities by 1·09 per cent. than the richest sample of American hops obtainable. There is reason to believe that in the season of 1934, as in 1933 and 1932, this variety was the richest in the world.

5. Two other new varieties, viz. 411 and Q43, were richer in preservative qualities by 0·98 per cent. and 0·82 per cent. respectively, than the richest sample of American hops obtainable.

6. Notes are given on certain new varieties which are being grown commercially or which show commercial promise.

7. A number of new varieties, suitable for cultivation in this country and heavy croppers, are equal or superior in preservative qualities to the imported American hops.

8. The incidence of Mosaic Disease and of Downy Mildew is recorded.

II. STATISTICS AND RECORDS

61. Records.

The preparation of material for a detailed report upon the apple rootstock investigations has occupied a large portion of the section's time during the past year. This work has entailed the examination and analysis of a body of records ever growing in volume. In addition, material has been prepared for reports on the plum rootstock experiments and various subsidiary apple rootstock trials.

The extension of work on such projects as " Incompatibility " and " Biennial Bearing ", has involved research into many of the older records of the Station in order that an examination can be made of the knowledge so far accumulated. Much of this work has fallen on the staff of the record office. The opportunity offered by a very light crop has been taken to bring up to date some extensive records, such as those of size and colour of fruit, which take a long time to summarize. Much help has been given in this work by members of the recording staff. (T.N.H. and J.L.E.)

Meteorology. An examination has been made of the twenty-one years' records of temperature available to determine how often, and when, damaging frosts in spring have occurred at this Station. An account of this is included in this report. (T.N.H.)

The usual data have been recorded in relation to the Agricultural Meteorological Scheme of the Ministry of Agriculture, and as a Station of the second order under the Meteorological Office, Air Ministry.

Summaries of the weather conditions of the year 1934 have been published (H24). (H.C.C.)

62. Technique of Recording.

The trial and improvement of sampling methods has continued. A short report on the sampling of fruit for size and colour has been published (E84) and a further report on sampling in relation to less easily recorded " vigour " records, such as wood growth, is being prepared. An apparatus for serial recording and counting in categories has been made to help with the shoot census records (see under 64). (T.N.H. and J.L.E.)

63. Plot Lay-out.

The uniformity trial of strawberries was completed last autumn, and a report is being prepared. In view of the sudden and widespread attack of the Yellow-edge virus disease, it was felt that the trial was not worth continuing further. It is doubly unfortunate that the frost prevented the harvesting of more than half a crop ; however, records of blossoming and vigour were added to those already accumulated.

The planning of field trials in accordance with methods previously described continues. Several interesting new experiments have been planned, particularly with strawberries, for which crop new experiments involving spraying, manuring and spacing have been designed.

A further experiment of interest has been planned in relation to bacterial die-back disease in Victoria plums (see under 3). (T.N.H. and J.L.E.)

PUBLICATION DURING THE YEAR.

EDGAR, J. L., and DE WET, A. F. "An Experiment in Sampling Technique for Size and Colour of Apples. Bramley's Seedling on Rootstock No. II, 1934 Crop." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 130-4. (E84.)

III. PLANT PHYSIOLOGY

64. Analysis of Growth Relation of Stock and Scion.

(*a*) *Relative Parts Played by Roots and Stem in Stock Influence.*

Observations are being continued on two series of double-worked trees, in which the root-systems of the stock have been combined with stems of the same stock or of a different stock, to determine which organ plays the major part in stock influence. (M.C.V.)

(*b*) *Time, Nature and Distribution of Summer Growth.*

A rapid method for recording summer growth in trees has been devised and a description of its application to apple trees has been published (F18). The growths are classified on the basis of obvious morphological and physiological characters into categories, each of which is given a letter of the alphabet as a distinctive symbol. Starting at the apex of the tree, each growth in turn is examined and its category recorded; the result is a map of the tree and a census of the numbers of growths of each category. The map is subdivided by stops into sections corresponding to the major and minor subdivisions of the branch system, so that each growth recorded can be readily found again on the tree. Successive maps are entered, one below the other, on the same sheets, so that the history of each individual growth can be followed through the season and correlated with its performance the next year. It was shown that the method reveals growth responses not easily detected by other means. The full results of the application of the method during three successive seasons to determine the response of apple trees to different stock and manurial treatments is being analysed and prepared for publication.

A device, that reduces work by automatically counting the categories as they are recorded, has been made and described in collaboration with Pomology (E89). It consists of a portable typewriter with reset counters attached to keys bearing the letters used as symbols for categories. (M.C.V.)

(*c*) *Seasonal Course of Root and Shoot Development.*

Analysis of the results obtained from the unworked apple stock No. XIII is being continued.

As foreshadowed in the last report, a repetition has been made of the experiment in which trees of two apple scion varieties, each on four rootstocks, were planted in spring and sampled in spring, summer and autumn. The results confirm the interesting difference in leaf/root ratio found on different stocks the previous season. The moisture content of the underground piece of stock stem has also been found to be consistently different in different stocks; a short preliminary account appears in this Report (p. 131).

(*d*) *Cambial Activity at the Union.*

This work has been discontinued for the present.

(*e*) *The Assimilation Rates of Apple Leaves.*

Work has been begun on the relative assimilation rates of apple leaves of different ages and in different positions on various scion-stock combinations. Methods for the measurement of the intensity of light at different positions in a tree are also being tested. (H.L.P.)

(*f*) *Absorption of Nutrient Salts by Roots.*

An investigation of the efficiency of apple roots has been begun, to determine whether those of different stocks absorb nutrients in different proportions. It is proposed to grow the trees with their roots in nutrient solutions of known composition and then determine the amount of each nutrient absorbed by analysing the residual solution from time to time, to find out what has been left behind. The Biochemistry Section is collaborating and will make a final analysis of the resulting tree (*vide* 66ii). Preliminary work is being carried out first to discover the best method of growing trees in solutions. (H.L.P., W.A.R. and M.C.V.)

(*g*) *Water Relations.*

Work on water absorption and water loss, in relation to stock and scion effect, has been resumed. (H.L.P. and M.C.V.)

(*h*) *Biennial Bearing.*

Work on the physiological causes, and on possible methods for control, of biennial bearing in apples is in progress, in collaboration with the Pomology, Biochemistry and Insecticides and Fungicides Sections. (P.K.S.)

65. Vegetative Propagation (with Propagation Section).

Hardwood Cuttings.

The experiments on methods for maintaining moisture conditions favourable for rooting and on the effect of time of planting are being continued as a matter of routine, for variations in results from year to year indicate marked seasonal effects.

The experiment on pear root cuttings is likewise being continued. The results so far obtained from the experiment on leaf removal indicate that it is better to plant the cuttings with leaves on. This experiment is being repeated. An experiment has been begun on the effect of warming the cutting bed with hot water pipes. The investigation into the course of root, leaf and stem growth in plum cuttings has been discontinued for the present. (R.J.G. and M.C.V.)

Layers.

Preliminary analysis of the results of the manuring and summer pruning experiments of last year has failed to show any marked improvement in rooting under any treatment, and no further work on these lines is in progress at the moment.

PUBLICATION DURING THE YEAR.

Vyvyan, M. C. "The Leaf Relations of Fruit Trees. II. The Census Method for Recording Summer Growth, with Special Reference to the Apple." Journ. Pom. and Hort. Sci. (November, 1935). **13,** 202-19. (F18.)

Summary.

1. An easy method for rapid recording of summer growth is described.

2. Growths are classified into categories on the basis of easily recognized characters such as order (primary or secondary), performance (bearing or non-bearing), activity (growing or non-growing), and size (short or long).

3. Each category is given a letter of the alphabet as a distinctive symbol.

4. Each growth in turn from the apex to the base of the tree or sample branch is examined and its category recorded ; the result is a census of growths of each category and a map of the tree.

5. The map is subdivided by full-stops, commas and brackets into sections corresponding to the major and minor subdivisions of the branch system.

6. Successive censuses can be recorded one below the other on the same sheet, and the history of individual growths thus followed through the season and correlated with their performance next season, and with their position on the tree.

IV. BIOCHEMISTRY

MUTUAL INFLUENCE OF ROOTSTOCK AND SCION.

66. Elementary Analysis.

Work has progressed along the lines indicated in the last report.

(i) Polarographic. Mr. Marsden of the Imperial College of Science, London, has isolated a number of sources of trouble and, with the help of the physics workshop of the College, has made drastic alterations to the polarograph, as a result of which he hopes to make the method suitable for routine use.

(ii) Spectrographic. A method has been worked out for converting the sample of wood, bark, etc., into small carbon electrodes between which electric sparks may be passed or an arc struck, to produce the spectrogram of the contained elements. This method, therefore, gives the spectrogram of the material itself without any superimposed spectrum due to the metallic or carbon electrodes of the usual methods. (W.A.R.)

67. Organic Analysis.

Professor R. Robinson, of Oxford, has identified a few preparations from apple bark, but it has not yet been possible to make any further preparations. (W.A.R.)

68. Tree Injection.

Distribution.

Further experience has been obtained in controlling the distribution of injected substances in branches or whole trees, and methods have been worked out for treating single leaves, or parts of leaves, each with a different substance. This work is being written up for publication. (W.A.R.)

Avoidance of Damage.

Up to this season serious damage due to overdose has been avoided by stopping any injection at the first sign of leaf symptoms, should they appear ; but early this year leaf symptoms did not appear until a week after the injection, so that no warning of the damage was given. This exceptional delay in appearance of symptoms became less marked as the season advanced until mid-summer, when they appeared within a day as in former seasons. The delay was, in all probability, connected with the lack of maturity of the foliage for some weeks after the May frost. (J.H., B.G.L. and W.A.R.)

Results of Injection.

(i) Artificial Manures. Injections done during the first flush of shoot growth resulted in marked increases in growth; but little or no increase in growth resulted from later injections. Experiments on the effect of time of injection are, therefore, being planned. A progress report has been published (K12). (B.G.L. and J.H.)

(ii) Iron salts for chlorosis. A chlorosis affecting trees grown in ordinary soil in pots was shown by the leaf injection method to be of the iron " shortage " type. Other facts suggest that the trees in the plantations may be suffering from slight iron " shortage ", and this possibility is being tested. A progress report has been published (K13). (W.A.R. and B.G.L.)

(iii) Nitrogenous Compounds. Trees were injected with equal amounts of nitrogen as ammonium nitrate, urea and asparagin respectively. Dr. Hulme of the Ditton Laboratory has shown that the fruit differed in both total nitrogen content and in the form in which the nitrogen was present. This experiment has demonstrated the possibility of varying at will the organic composition of fruit and so has made possible experiments on the connection between chemical composition and storage quality, disease resistance, etc. (W.A.R.)

(iv) Nutrients and Disinfectants against Silver Leaf. The results of injection of nutrients and the disinfectant 8-hydroxyquinoline potassium sulphate, both alone and together, into plum trees suffering from silver leaf have been sufficiently hopeful to justify definite experiments being carried out next season. (W.A.R. (with H.W.))

(v) Insecticides against Woolly Aphis (see Entomology Section).

(vi) Work has been started on the effects of treating Cox's Orange Pippin apple trees on XII and XVI with ammonium molybdate both by injection and by application to the soil. (W.A.R.)

(vii) Biennial bearing (see Physiology 64*h*). (W.A.R.)

Dosage.

Experiments have been started to study the effect of size of dose on similar trees and to work out a system of dosage based on tree size. (J.H., B.G.L. and W.A.R.)

WOOLLY APHIS.

69. Causes of Immunity to Woolly Aphis.

See under VI, Entomology.

ABSORPTION OF NUTRIENTS BY ROOTS.

See Physiology (64*f*). (W.A.R.)

PUBLICATIONS DURING THE YEAR.

Roach, W. A. " Tree Injection. Invigoration by the Injection of Fertilizers. A Progress Report." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 135-8. (K12.)

Roach, W. A. " Tree Injection. The Diagnosis and Cure of Chlorosis in a Peach Tree." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 139-41. (K13.)

V. PLANT PATHOLOGY, MYCOLOGY AND BACTERIOLOGY

PATHOLOGY OF TOP FRUITS.

70. Crown-gall.

Further observations have been made on galls occurring on various host plants. A severe infection of the stems of cultivated blackberries has been studied. (H.W.)

An experiment has been started to test the value of organic mercurials when applied to apple stocks at the time of planting in the nursery, as a protection against the development of crown-gall on the cut surfaces at the base of the stocks. (H.W. and R.J.G.)

Relative Susceptibility of Apple Stocks.

An analysis of the completed data from the second experiment in the series (referred to in the 1930-1 report) showed a marked difference in vigour of growth between two parallel sets of inoculated and of uninoculated No. VII stocks, irrespective as to whether a gall had subsequently appeared on the former or not, suggesting that the pathogen may be active in a tree in the absence of a visible gall. In view of this result it was decided to postpone publication pending a further confirmatory experiment which was commenced in 1935. In this experiment groups of four varieties of Malling stocks with widely contrasted susceptibilities to crown-gall were wound-inoculated in pots under uniform greenhouse conditions, with strains of *Bacterium tumefaciens* isolated from apple and from raspberry respectively, and further groups of trees of each stock were wounded without inoculation. Detailed measurements of each tree were made before inoculation and similar records will be made from time to time over a two year period when the trees will be lifted and examined for the incidence of galls.

(R.V.H.)

71. Brown Rot.

A wilt of plum shoots in nursery stools and layer beds has been studied for some years. An account has been published (C106). *Sclerotinia laxa* has been isolated from such shoots and it was ascertained that the disease could be reproduced by inoculating the lower leaves with the fungus at the time the shoots were earthed up. (H.W.)

A rot of plums during cold storage was investigated and found to be caused chiefly by *Sclerotinia fructigena*, though other fungi, including *Sclerotinia laxa*, were also present. Recommendations for reducing losses under such conditions have been made (C109).

(H.W. and A.C.P.)

During the year a survey of our present knowledge of the Brown Rot Fungi and the disease they cause has been published in the form of a Bulletin (C107). (H.W.)

72. Silver Leaf.

(*a*) Injection experiments in relation to this disease have been started (see 68).

(W.A.R. and H.W.)

(*b*) *A "Papery Bark Canker" of grafted apple trees.* Observations have been made on cankers which appear on grafted apple trees. The outer layers of the bark peel off in a thin sheet (Papery Bark) and the wood is discoloured. In some cases this condition is associated with silvering of the foliage on the twigs in the neighbourhood of the cankers and it is suspected that the Silver Leaf fungus, *Stereum purpureum*, may be the cause; the relation that this fungus bears to the killing of the grafts is being investigated. The symptoms of this disease are very similar to those shown by a cankering of grafted apples in Australia and Tasmania and attributed to *Polystictus versicolor*. (H.W. and R.J.G.)

73. Influence of Stock on Scion.

In relation to disease see 97. (M.H.M.)

74. Bacterial Diseases of Fruit Trees.

Bacterial Canker of Plum Trees.

Experiments by means of pot cultures and field plots have been continued to ascertain whether cultural conditions modify the predisposition of trees to Bacterial Canker. Trees growing in sand cultures with various manurial treatments have been tested by direct inoculation with *Pseudomonas mors-prunorum*. All the trees became severely cankered except those where phosphate was omitted. (See p. 146).
(R.J.G., F.H.B. and H.W.)

Bacteriosis of Cherry Trees.

The study of the incidence of bacterial infection of cherry trees has been continued for a comparison of the causal organisms with those causing Bacterial Shoot Wilt and Bacterial Canker in plum trees.

On acid cherries an outbreak of Leaf Spot and Blossom Blight has come under investigation. The organism found associated with this infection shows, in preliminary cultural tests, certain characters different from those of the two organisms causing bacteriosis in plums. (H.W. and N.H.G.)

Tests of Bactericides.

Various bactericides have been tested *in vitro* against *Ps. mors-prunorum*, and a short report published (C110); some of these have proved to be lethal at low concentrations. (H.W.)

Spraying Trials.

Spraying experiments have been initiated on this Station and in a grower's plantation to test the value of spraying with Bordeaux mixture in controlling Bacterial Leaf Spot and Canker in cherries. (N.H.G., M.H.M. and H.W.)

PATHOLOGY OF SMALL FRUITS.

75. Non-parasitic Disorder of the Raspberry.

Severe outbreaks of a form of disease referred to in previous reports as "die-back" and "black root-rot" occurred in many localities in the early spring of 1935.

In collaboration with the Pomology Section, an experiment was started to determine the possible causal relation of abnormally contrasted soil moisture conditions and this disease. For this purpose soil chambers were erected in which series of Lloyd George raspberry stools are being subjected to varying degrees of soil moisture, using the recently available Roger's Soil Moisture Meter for standardizing the conditions.

(R.V.H.)

76. Raspberry Mosaic Disease.

See special report on Raspberries under IX.

77. Loganberry Cane-spot.

See under "Loganberries, Blackberries and Dewberries", XI.

78-79. Strawberry Diseases.

See special report on Strawberries under X.

MISCELLANEOUS.

80A. Verticillium Wilt of Hops.

Further outbreaks of this disease have been reported during 1935 and as a result of surveys of the affected gardens additional data on the etiology and control of the disease have become available, on the basis of which experiments have been started to determine the possibility of control by improvements in soil drainage and the use of resistant varieties.

An account of this disease appears on p. 158 of this Report.

(R.V.H.)

80B. Walnut Graft Disease.

The morphology, cultural characters, and physiology of the fungus *Chalaropsis thielavioides* have been described, together with an account of the damage it causes to young grafted walnut trees. It invades the trees at the union and causes the death of the scion. It is shown that the disease can be reproduced by inserting the fungus at the union at the time of grafting. Disinfecting the greenhouse where the young trees are raised, using one per cent. formalin, and treating the stocks and the scion material also with one per cent. formalin, have proved satisfactory means of controlling the disease (E85). (J.B.M.)

PUBLICATIONS DURING THE YEAR.

Wormald, H. "The Brown Rot Disease of Fruit Trees." Min. Agric. Bull. 88 (January, 1935), 50 pp. (C107.)

Summary.

This is a detailed account of the Brown Rot fungi, *Sclerotinia fructigena*, *S. laxa* and *S. fructicola*, and the fruit tree diseases they cause. The bulletin deals with the History, Nomenclature, Geographical Distribution, Morphology, Culture and Physiology of the Brown Rot fungi, the Conditions conducive to Infection, Mode of Entry into Host Plant, Fungi related to the Brown Rot fungi, Losses due to the Brown Rot diseases, Host

Plants (all the important hosts are treated separately and the various diseases produced by these fungi on these hosts are described) and General Considerations of Control Measures.

WORMALD, H. "Further Studies on the Brown-Rot Fungi. VII. A Shoot Wilt in Stools and Layer Beds of Plum Stocks, and Its Relation to Wither Tip." Journ. Pom. and Hort. Sci. (March, 1935). **13,** 68-77. (C106.)

SUMMARY.

A Shoot Wilt in stools and layer rows of plum stocks was observed in the summer of 1924 at East Malling.

Lesions containing fungal mycelium were found on the underground parts of the affected shoots and *Sclerotinia laxa* was isolated from the tissues of the lesions.

Typical Wither Tip, caused by the same fungus, was also found on certain stools on the same plot.

Experiments have shown that both conditions can be induced by inoculating punctured leaves with conidia of the fungus.

Shoot Wilt was produced on stools in pots by inoculating leaves and then adding soil to the pots to cover such inoculated leaves.

It is recommended that stool and layer beds of plum stocks be laid out as far removed from established plum trees as possible. Any shoots showing Wither Tip should be cut back or pulled up.

WORMALD, H. "The Development of Scab in Stored Apples." Journ. of Min. Agric., 1934, **41,** 551-6, and E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 232-5. (C105.)

WORMALD, H. "Notes on Plant Diseases in 1934." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 142-7. (C108.)

WORMALD, H., and PAINTER, A. C. "Brown Rot of Plums in Cold Storage." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 148-50. (C109.)

WORMALD, H. "Preliminary Laboratory Tests of Bactericides on the Plum Bacterial Canker Organism." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 151-5. (C110.)

HARRIS, R. V. "Some Observations on the Raspberry Disease Situation in North America." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 156-64. (C111.)

HAMOND, J. B. "The Morphology, Physiology and Mode of Parasitism of a Species of Chalaropsis Infecting Nursery Walnut Trees." Journ. Pom. and Hort. Sci. (June, 1935). **13,** 81-107. (E85.)

SUMMARY.

The constant appearance of a fungus with two spore forms, on young walnut trees that failed to grow after grafting, suggested that this fungus was the cause of the failure.

The organism was isolated in pure culture and its relation with the disease investigated. The genetic connection between the two spore forms was established, and the fungus was found to be a species of *Chalaropsis*.

Three other strains of *Chalaropsis* and a species of *Thielaviopsis* have also been grown in culture; their morphological characters and cultural relations have been compared.

The appearance of naturally-infected walnut tissues and the distribution of the fungus in them are described.

Inoculations on walnut grafts gave positive results and definite evidence was obtained that the fungus is the cause of the disease. The carrot strain was the most virulent as a parasite of carrots.

Laboratory control tests showed that formalin at low concentrations is toxic to *Chalaropsis*. It is now generally used for controlling the disease.

The resemblance between the strains of *Chalaropsis* described in this paper and Peyronel's lupin fungus appears to justify the name *Chalaropsis thielavioides* for all these forms. The probable distribution of the fungus is discussed.

WORMALD, H. "A Slime Fungus found on Strawberry Leaves." Gardeners' Chron. (November 8th, 1935). **98,** 339. (C115.)

SUMMARY.

An infestation by a Slime Fungus of strawberry leaves on plants growing in the greenhouse, came under observation. The organism proved to be *Physarum cinereum,* which, in its plasmodium stage, developed on the debris of the old leaves and crept up the leaf-stalks to form its fructifications.

HARRIS, R. V. "Growing Healthy Raspberries—The Control of Diseases and Pests." Report of the R.H.S. Conference on Cherries and Soft Fruits, Varieties and Cultivation in 1935. 95-107. (C116.)

SUMMARY.

Short descriptions are given, with advice on control measures, of the following diseases and pests of the raspberry: (1) Blue Stripe Wilt (*Verticillium Dahliae*), (2) Dwarf Lateral Scorch, Black Root-rot and Crown-rot (non-parasitic and induced by unfavourable soil and weather conditions), (3) Cane-spot (*Elsinoë veneta*), (4) Spur Blight (*Didymella applanata*), (5) Raspberry Moth or Red Bud Maggot (*Lampronia rubiella*), (6) The Raspberry Beetle (*Byturus tomentosus*), (7) Raspberry Mosaic. Special reference was made to the last mentioned as this is the most serious of these diseases in Great Britain. The relative susceptibility of certain varieties of raspberries to the diseases is briefly discussed.

VI. ENTOMOLOGY

81. Red Spider.

The Hop Red Spider.

Investigations of a preliminary nature have been made upon this mite, and the results obtained have resulted in the control of the mites in the commercial hop garden. New points on the life-cycle have also been ascertained.

A progress report has been prepared. (A.M.M.)

82. Woolly Aphis.

Life History.

Observations have been made throughout the year with particular reference to the reasons for failure of routine control measures, and to the occurrence and spread in the nursery. Similar observations made in 1934 have been published (D110). (R.M.G.)

Control in the Nursery.

(*a*) Observations have been made on the cleaning of nursery stock by dipping and fumigating, including limited experiments to confirm toxicity to the insect and more extended tests to determine the limit of safety to the plants.

(*b*) Preliminary tests of soil insecticides for control of the aphis on the stool beds were carried out. (R.M.G.)

Spraying.

Field spraying trials of winter washes and single tree tests of summer contact insecticides (sprays and dusts) have included a continuation on a field scale of work with materials tested in the laboratory last year, the results of which have been published (D113). (R.M.G.)

Tree Injection.

Preliminary tree injection experiments suggest the possibility of controlling the insect without damaging the tree. (R.M.G. and W.A.R.)

Resistant Seedlings.

1,016 seedlings and 177 stocks raised from seedlings were tested for resistance to Woolly Aphis by weekly inoculation with the aphis under greenhouse conditions. Of the seedlings 402 were raised at the John Innes Horticultural Institution, Merton, and 614 by the Plant Breeding Section at East Malling. The stocks were raised at the École d'horticulture de l'État, Vilvorde, Belgium. (R.M.G. and A.M.M.)

Woolly Aphis Parasite.

No new trials have been carried out but farms where the parasite has been liberated were kept under observation. (R.M.G. and A.M.M.)

Causes of "Immunity" of Apple Varieties to Woolly Aphis.

This work has been in abeyance for this year and will be continued during 1936. (R.M.G., A.M.M. and W.A.R.)

83. Impregnation of Corrugated Cardboard Bands.

These investigations have been continued to ascertain whether the promising results obtained last year against weevils and Codlin larvae could be repeated on a field scale. A progress report on this work has been published (D112).

It is of interest to note that all the promising results of last year have been confirmed and that none of the treatments caused any sign of damage to the stems of the trees. The important treatments also were not "worked" appreciably by birds, mice, etc.

A new treatment, namely β-naphthol, gave very promising results against larvae of the Codlin Moth. (See p. 177 of this Report. A note has also been published in relation to other insects found in the bands (D111). (R.M.G. and A.M.M.)

84. Tortrix Investigations.

Owing to lack of crop no observations have been made this year. (A.M.M.)

85. A Study of the Vectors of "Reversion" of Black Currants.

This investigation is in abeyance until suitable material is available. (A.M.M.)

86. Mites.

Systematic Study of Gall Mites.

A systematic study of the Gall Mites which infest plants has been continued, and material has been secured from India and elsewhere. An unknown species has been reported on Ivy, but sufficient material has not been forthcoming to describe the species.

Brief notes on some important Mite and Insect Pests occurring on fruit trees and bushes have been prepared (D103). (A.M.M.)

Tarsonemid Mites.

A few more species have been added to the small collection available at East Malling, and it is proposed to work on the group in detail when sufficient material comes to hand. (A.M.M.)

87-91.

See joint reports under IX and X.

PUBLICATIONS DURING THE YEAR.

Massee, A. M. "The Occurrence of *Aradus aterrimus* Fieb. in Kent in 1933-4." Ento. Mon. Mag. (February, 1935). **61**, 41.

Summary.

This rare bug which has not been taken previously for seventy years, was found in some numbers in some old charcoal bags in Oaken Wood, East Malling.

Massee, A. M. " On the Transmission of the Strawberry Virus ' Yellow-Edge ' Disease by the Strawberry Aphis, together with Notes on the Strawberry Tarsonemid Mite." Journ. Pom. and Hort. Sci. (March, 1935). **13,** 39-53. (D105.)

Summary.

1. Experiments on the transmission of the strawberry virus " Yellow-edge " disease by insects and mites are described.

2. The Strawberry Aphis (*Capitophorus fragariae* Theo.) is shown to be a vector of " Yellow-edge " virus.

3. The aphis is able to transmit the virus in June, but the evidence so far collected tends to suggest that it is not able to transmit the virus during the latter part of July and August.

4. One hundred per cent. of healthy clonal Royal Sovereign plants showed virus symptoms when inoculated with aphides from virus plants.

5. Only one plant showed virus symptoms when inoculated with aphides from healthy plants.

6. One hundred per cent. of the absolute " control " plants remained healthy throughout the experiment.

7. Direct aphis injury, while showing characteristic symptoms, did not cause any material harm to the plants.

8. The Strawberry Tarsonemid Mite (*Tarsonemus fragariae* Zimm.) did not transmit the virus in the 1933-4 trials ; in each case negative results were obtained.

9. The Strawberry Tarsonemid Mite, however, may cause severe direct injury to the plant, masking any virus symptoms which may be present. For these reasons the mite may be very important.

10. A technique has been worked out whereby certain insect transmission experiments can be conducted in the open, without the aid of an insect-proof greenhouse.

Massee, A. M. " Notes on Mite and Insect Pests for the Year 1934." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 165-72. (D103.)

Massee, A. M. " Notes on the Strawberry Aphis (*Capitophorus fragariae* Theo.). Appendix—Bibliography of papers dealing with Aphids on Strawberries, by F. J. D. Thomas." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 173-9. (D106.)

Greenslade, R. M., Massee, A. M., and Thomas, F. J. D. " Apple Blossom Weevil Experiments in 1934. Impregnation of Tree Banding Materials." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 180-4. (D112.)

Greenslade, R. M. " Laboratory Trials of Wetters against Woolly Aphis, *Eriosoma lanigerum* (Hausm.)." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 185-90. (D113.)

Greenslade, R. M. " Observations on Woolly Aphis (*Eriosoma lanigerum* (Hausm.) in 1934." E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 236-8. (D110.)

Massee, A. M., Thomas, F. J. D., and Hey, G. L. " The Fauna of the Weevil ' Sack-Band '. II." Annals and Mag. of Nat. Hist. (September, 1935). **16,** 350-4. (D111.)

Summary.

Some hundred additional species of insects have been recorded from weevil " sack-bands " since the publication of Part I in 1930.

Some uncommon species have been found hibernating in the sacking and corrugated cardboard bands, and the trapping method is suggested as an additional method to those frequently used for collecting insects.

The correct method of applying the bands is outlined.

MASSEE, A. M. "Notes on Some Pathological Troubles of the Royal Sovereign Strawberry." Report of the R.H.S. Conference on Cherries and Soft Fruits, Varieties and Cultivation in 1935. 40-7. (D115.)

SUMMARY.

A brief review is given of the more common insect pests and diseases which have been studied at East Malling during the past six years.

They are: (1) The Strawberry Red Spider; (2) The Strawberry Tarsonemid Mite; (3) The Yellow-edge (virus) Disease; and (4) The Delicate Strawberry Aphid.

Of these the Yellow-edge (Virus) Disease is considered the most important, while the Delicate Strawberry Aphid is shown to be a vector of Yellow-edge. The Strawberry Tarsonemid Mite may cause direct injury to the plants in warm, dry summers; it is also important because its direct effect on the plant tends to mask any symptoms of virus which may be present.

VII. INSECTICIDES AND FUNGICIDES*

LABORATORY INVESTIGATIONS.

93, 98, 99, 100. INSECTICIDES.

Methods of Testing.

Work has been continued on the development of methods for testing insecticides under standardized conditions. Progress has been made chiefly in regard to the testing of ovicides and of contact insecticides. (W.S.)

Chemical Aspects.

Preliminary experiments have been carried out with a view to obtaining more information on the relation of chemical constitution to insecticidal action. Several series of organic compounds will be further investigated as opportunity arises.

The examination and determination of spray residue on loganberries treated with a spray containing a copper preparation (see 77) and on pears after a late lead arsenate spray were carried out. (H.S.)

Tests of Ovicides.

A promising beginning has been made on the examination of the toxic properties of low temperature carbonization tar oils (with the co-operation of the Fuel Research Station, Greenwich). Various fractions of a low temperature tar and its hydrogenation product, together with the isolated neutral, basic and acidic fractions have been examined in a preliminary survey. The ovicidal properties of some materials obtained from industrial sources have also been investigated. (H.S. and W.S.)

Tests of Contact Insecticides.

An investigation of the toxicity of certain thiocyanates, nicotine derivatives and chlorinated naphthalenes has been started. Of the substances so far tested, one (monochlornaphthalene) has already been selected for more extensive tests. (H.S. and W.S.)

Work on the correlation of the chemical properties of Derris root with its toxicity to Lepidopterous larvae has been continued in collaboration with Dr. Tattersfield of the Rothamsted Department of Insecticides. (W.S.)

Tests of Stomach Poisons.

No intensive work on the testing of new stomach poisons has been attempted and none is contemplated until the methods of testing reach a more satisfactory stage of development. (H.S. and W.S.)

* In preparing the Report for this Section it has been found convenient to group certain projects; the numbers therefore are not serial.

95. Fungicides.

Methods of Testing.

An attempt has been made to evolve a standard method for testing protective fungicides using Bordeaux mixture as the test fungicide and *Venturia inaequalis* (conidia) as the test fungus. The method is not yet perfected, but, in standardizing each phase, considerable information has been obtained regarding the technical, cultural and manipulative aspects of the problem (C113). (H.B.S.M. and M.H.M.)

FIELD INVESTIGATIONS. I. MODIFICATION OF ROUTINE CONTROL MEASURES.

96a. Insecticide-Fungicide Programme for Cox's Orange Pippin.

In 1934, the following results were obtained (C112):

(*a*) Two pre-blossom lime-sulphur sprays (applied at green-bud and at pink-bud) were again more efficacious against Scab than one similar spray (applied at pink-bud).

(*b*) Of three spreaders (sulphite lye, sulphonated lorol, and "Lethalate" Standard Wetting Preparation of declared composition) compared as addenda to the lime-sulphur spray, no one product showed marked superiority over another. Nicotine included at petal-fall gave excellent control of Apple Sawfly in the egg stage.

In 1935, a similar trial on the same trees gave scanty results because the crop was almost all destroyed by frost. Observations on the leaves and on the light crop indicated that two pre-blossom lime-sulphur sprays were once again more efficacious than one, and that lime-sulphur without a spreader was slightly more effective than lime-sulphur with "Lethalate" Standard Wetting Preparation or with petroleum oil (emulsified with sulphite lye). Lime-sulphur with emulsified petroleum oil caused severe defoliation (see pp. 191-7). (H.B.S.M. and M.H.M.)

96b. Spreader Trials—Apple Scab.

A trial of the merits of seven different spreaders (with a "no-spreader" treatment as control) as addenda to the standard lime-sulphur spray gave inconclusive results, for the crop was ruined by frost. Estimations of Scab were made on the leaves, and the results showed no significant difference between treatments. The trees concerned were young Worcester Pearmain, Edward VII, Allington Pippin and Newton Wonder, all on No. IX stock. (H.B.S.M. and M.H.M.)

96, 100. Mitigation of Spray-Damage.

By addition of Ferrous Sulphate.

Frost also ruined the crop of Cox's and Worcesters on stock No. II in a re-planned trial designed to show whether the inclusion of ferrous sulphate in the lime-sulphur spray (with or without lead or calcium arsenate) protected the trees from lime-sulphur or lime-sulphur-arsenate damage. Promising results were obtained, however, for all sprays containing ferrous sulphate were safe, while those not containing ferrous sulphate caused severe leaf-drop. Zinc sulphate proved to be an unsatisfactory alternative to ferrous sulphate. Evidence was forthcoming that the inclusion of ferrous sulphate did not impair the fungicidal or acaricidal value of the relatively strong lime-sulphur with or without arsenate. Control Cox trees (unsprayed) were severely attacked by Scab and by Red Spider. (H.B.S.M. and M.H.M.)

In parallel with the field experiments on modified lime-sulphur-arsenate sprays, chemical analyses of the various mixed sprays are being made in the laboratory with a view ultimately to correlating the observed behaviour in the field with the chemical composition of the sprays. (H.S.)

By Reduction of Spray-concentration.

In another field trial on a smaller scale on Cox's Orange Pippin trees, lime-sulphur and Bordeaux mixture were used at concentrations much weaker than those normally employed in commercial practice. A 2-3-100 Bordeaux mixture (three times) and a 1 per cent. lime-sulphur (three times) gave good Scab-control but caused some defoliation during the latter part of June. Petroleum-oil emulsion used as spreader and sticker, and "Lethalate" Standard Wetting Preparation, as spreader, did not noticeably influence the degree of Scab-control obtained. The crop on these trees also was ruined by frost, and estimations of Scab were made on the foliage.

(H.B.S.M. and M.H.M.)

94. Combined Sprays for Loganberries.

In collaboration with the Mycology Section work has been continued on the simultaneous control of Cane Spot and Raspberry Beetle. A report on part of this work has been published (D107). (W.S. and R.V.H.)

FIELD INVESTIGATIONS. II. TESTS OF NEW SPRAY MATERIALS.

94, 96, 98. Phytocide Trials.

A large number of spray-materials were investigated alone, and in various combinations, to test their phytocidal properties by means of a recently-devised, single-branch technique. Most of these materials were obtained from commercial sources. Those found to be sufficiently non-phytocidal will be selected for further trial.

(H.B.S.M., M.H.M., H.S. and W.S.)

96. Insecticide-Fungicide Trials.

Preliminary Tests of Fungicidal properties.

Three new products, selected from the 1934 phytocide trials, were tested in a statistically-planned field trial against Scab. The trees were young Worcester Pearmain, Edward VII, Allington Pippin and Newton Wonder, all on No. IX stock. The control trees were sprayed with lime-sulphur or with Bordeaux mixture. None of the three new products compared favourably with these standard fungicides. Scab-estimations on the foliage were the basis of comparison, the crop (except for that on the Scab-resistant Edward VII) being ruined by frost (see pp. 198-203). (H.B.S.M. and M.H.M.)

FIELD INVESTIGATIONS. III. BIOLOGY AND CONTROL OF SPECIFIC PESTS AND DISEASES.

92, 94. Codling Moth.

Observations were made on the habits of this pest under local conditions with a view to devising practicable control measures. In 1935 no field spraying trials were possible on apples, but one successful trial was carried out on Conference pears. In this experiment an infestation of 14 per cent. was reduced to 3 per cent. by a single application of lead arsenate. (W.S.)

94. Plum Sawfly and Apple Tortrix.

No trials against these pests could be carried out in 1935 on account of the disastrous May frost. (W.S.)

96. Brown Rot in Morello Cherries.

Bordeaux mixture and lime-sulphur, each with and without a spreader, were compared, one application of spray being made just pre-blossom. Bordeaux mixture proved safe but lime-sulphur caused damage, burning some of the leaves and the unopened flower-clusters. The results concerning Brown Rot were promising. (H.B.S.M. and M.H.M.)

96. Strawberry Mildew.

Spraying with lime-sulphur of various strengths (with spreader) was compared with sulphur dusting. The disease, already well established when the treatments were applied, was checked more by the wet sprays than by the dust. The influence of these products as protective fungicides will be tested in a future trial. (M.H.M.)

96. Bacterial "Shot-hole" and Canker in Stone Fruits.

A preliminary trial on Bigarreau de Schrecken, where autumn, spring and autumn and spring spraying with Bordeaux mixture were compared, showed that a slight reduction in new cankers resulted from a late spray-application in autumn, while an application just pre-blossom caused reduction in the amount of "shot-hole" recorded on the leaves in summer. (M.H.M.)

97. Apple Scab.

No information was obtained on the effect of rootstock and manurial treatment on account of lack of crop through frost-damage. (H.B.S.M. and M.H.M.)

97a. "Fruit-russeting" and "Branch-blister" Disease.

Branch-blister disease has assumed serious proportions in parts of Essex during the past two years, especially on young Cox's Orange Pippin trees on stock No. II. There is evidence that soil-type and weather conditions are important governing factors, and experiments designed to give information on the influence of these factors have been undertaken in Essex in collaboration with the County authorities.

Records made on young Cox's Orange Pippin trees at East Malling revealed that those on stock No. IX showed more blister than those on No. I, on No. V or on No. XII, while trees lacking potash were more severely affected than those receiving potash dressings.

While the possibility that the disease is primarily of fungal origin is remote, inoculations (which have previously given inconclusive results) with the associated fungus-types will be resumed, using potash-deficient trees worked on a susceptible rootstock.

Owing to severe frost in May, which destroyed most of the crop, data concerning the distribution of fruit-russeting, and its possible relationship with branch-blister, were not obtained. (M.H.M.)

PUBLICATIONS DURING THE YEAR.

MOORE, M. H., and MONTGOMERY, H. B. S. "A Field Spraying Trial of Combined Fungicide-Contact-Insecticide Sprays in 1934." A Progress Report. E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 208-16. (C112.)

MONTGOMERY, H. B. S., and MOORE, M. H. "On a New Method for Precision Testing in the Laboratory of the Toxicity of Lime-Sulphur and of Bordeaux Mixture as Protective Fungicides." A Progress Report. E. Malling Res. Sta. Ann. Rep. for 1934 (May, 1935). 217-22. (C113.)

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VIII. EXTERNAL CONTACTS

101. Enquiries and Visitors.

During 1935 1,653 enquiries on advisory matters were answered through the post in addition to numerous enquiries which were dealt with by telephone. Over 3,400 visitors were received at the Station, including 44 organized parties and 120 visitors from overseas. In addition 33 post-graduate workers visited the Station for study periods varying in length from a few days to a year. (N.B.B., H.C.C., and the staff in general.)

102. Conferences, Demonstrations and Lectures. Exhibits and Publications.

A two days' demonstration of spraying machines and tractors was held in March and gave an attendance of over 600. A Soft Fruit Open Day was held in July and a Conference on the subject of Frost Damage was held in September. Members of staff have given twenty lectures in the course of the year on various aspects of the research programme, and educational exhibits have been staged at five agricultural or horticultural shows in different parts of the country. Some fifty publications including research bulletins and popular articles have been issued, and notes on topical subjects have been sent to the Kent N.F.U. Journal throughout the season. Further details with regard to the Station's external contacts together with an account of work done in collaboration with other research stations, outside trials, and distribution of horticultural material will be found in the Supplementary Annual Report.

IX. RASPBERRIES*

(Combined Pomological and Pathological Investigations.)

42. Variety Trials.

Recent additions to the variety collection have consisted mainly of new American varieties, partly of Lloyd George parentage. One Continental variety has also been planted.

It is believed that one or two varieties which, as grown in England, appear to be always infected with mosaic have been obtained free from the disease from New Zealand. Owing to the difficulty of positively identifying varieties not previously seen as free from mosaic—leaf distortion being absent—the identity of at least one of these is still in doubt. (N.H.G.)

47. Breeding.

A report (Esf. 28) has been published during the year. Thirty-five families of seedlings raised over a period of thirteen years have cleared up several preliminary problems, and provided improved methods for future work. Seedlings produced by "selfing" named varieties have shown that the most promising results are not always obtained from the best commercial varieties, and that the varieties giving most promise as parents when "selfed" may not be the best when crossed with each other. The most hopeful results so far have been obtained by crossing selected "selfed" seedlings of different parentage.

It is hoped that seed obtained by further selfs and crosses made in 1935 will yield half a dozen families for planting out in 1936. (N.H.G.)

50. Propagation.

Virus-free plants of three further varieties have been marked for clonal propagation. (N.H.G. and R.V.H.)

59. Manuring.

A combined seedling and manurial trial was planted out in the winter of 1934-5. Four seedlings, with two named varieties as controls, are receiving various potash dressings differently distributed over a period of four years. (W.A.B. and N.H.G.)

76. Raspberry Mosaic Diseases.

General.

Pending the issue of detailed reports in course of preparation, a brief summary of the raspberry disease situation in Eastern Canada and U.S.A., with special reference to virus disease, has been published, based on observation and experiments carried out during a year's residence at St. Catherines, Ontario, under an exchange arrangement.

* In the collaborative work under IX, X and XI the numbering is not serial; the numbers refer to the projects in the various sections concerned.

The situation in the East is further contrasted with that in the Canadian West and in Great Britain (C111).

Etiology.

The analysis of symptoms by grafting methods has been continued with special reference to determining the relation between the mosaic diseases occurring on raspberry in Great Britain and in North America (work commenced at St. Catherines, Ontario, in 1933) and the type of mosaic occurring on the highly resistant variety *Red Cross*.

Experiments in Commercial Control.

A further survey of the Research Station cane-nurseries and of the five extension nurseries in Kent and Sussex (now in their fifth year) was made, and the results indicated that in quality, vigour and freedom from disease the output of these propagating centres has been well maintained. (R.V.H.)

88. Raspberry Insects.

Experiments with a raspberry aphid (*Amphorophora rubi* Kalt) to determine its possible function as a vector of mosaic disease have been continued after a lapse of some years. (A.M.M.)

X. STRAWBERRIES

(Combined Pomological and Pathological Investigations.)

44. Classification, Nomenclature and Variety Trials.

Clonal races of important varieties and " strains " are under observation. (W.S.R.)

48. Breeding.

Several further crosses have been made between Royal Sovereign, Sir Joseph Paxton and Lefebvre with the object of obtaining disease-resistant seedlings of high quality. Seedlings from crosses made in 1934 between seedlings resistant and susceptible to Yellow-edge disease, with the object of determining whether susceptibility to Yellow-edge is controlled by genetic factors, have yielded some interesting results. The greater apparent susceptibility to Yellow-edge of seedlings from crosses between parents showing Yellow-edge symptoms, suggests that susceptibility may be inherited. This work is being continued.

Observations of fruit characters, disease resistance, etc., were made on plants from fifty selected seedlings, raised at the Horticultural Research Station, Cambridge, chiefly crosses between American and English varieties. They proved extremely susceptible to disease under our conditions and have been discarded. (H.M.T.)

52. Propagation.

The establishment of Virus-free Clones.

A good yield of runners was obtained from isolated runner beds of Royal Sovereign. Unfortunately a late spread of the Yellow-edge virus made drastic roguing necessary, but the method of laying the runners into small blocks separated by cultivated alleys enabled this to be done efficiently. If this method of runner raising had not been introduced roguing would have been practically impossible. It has been decided that it will be wiser to keep the bulk of the runners under observation at the Station for another year before releasing them in quantity.

The virus-rogued clone of Tardive de Leopold is being propagated in larger numbers, and clones of two strains of Paxton, Huxley, Madam Lefebvre, Stirling Castle, Western Queen, and a number of recommended strains of Royal Sovereign are being increased. A preliminary nursery trial has been planted to obtain initial information on their behaviour at East Malling. (W.S.R. and R.V.H.)

Individual Plant Studies of Clonal Families.

A final year's records on the behaviour of the plants of certain clonal families have been obtained on some 2,000 plants, whose whole life history from the time of their formation has been individually recorded. Owing to the frost the 1935 crop was very small, and the late spread of virus noted above has made it undesirable to leave the plants in position longer. The analysis of the vast amount of data gained from

the five years' records will now be undertaken. As reported previously there seems ample evidence that, *provided the plant becomes established*, its position on the parent stolon or the time of its formation has little effect on its later history. It is, however, risky to plant small late-formed runners under unfavourable conditions, as they are more severely checked thereby than large runners. (W.S.R. and J.L.E.)

Uniformity Trials.

The records from the above trial will also be analysed from the point of view of determining the ideal size and shape of plot for strawberry experiments. (J.L.E.)

Effect of Age of Parent and Spacing of Runners.

In this trial runners from one and two-year-old parents, and runners that were spaced and unspaced in the runner bed have grown into plants that are quite alike in vigour and blossoming. They will crop for the first time in 1936. The trial was planned for the superimposing of three spray treatments, and these have given useful preliminary results as reported below under aphid investigations. (W.S.R.)

57. PLANTING, ETC.

Time of Planting in Relation to Warm Water Treatment.

This has been investigated by planting a trial of treated and untreated runners, graded into two sizes, every month from September, 1934, to April, 1935. The untreated runners bear out previous findings that the earlier the strawberries are planted the more vigorously they grow. The warm water treated runners show that, when this treatment is given, early autumn planting gives best results, and that winter planting results in heavy losses. Spring planting was less satisfactory than early autumn, but more satisfactory than winter planting.

Certain treated and untreated plants were dug up at intervals for root analysis. These records suggest that warm water treatment imposes a check on new root growth of about three weeks in autumn, longer in winter (when root growth is slow in any case) and rather less in spring.

The practical recommendation is to carry out the warm water treatment in early autumn if possible, but if this is not possible to wait till spring rather than treat in the winter.

Such time of planting trials obviously need repeating over a number of seasons, and a repetition is now under way. (W.S.R., A.M.M. and M.E.R.)

Effect of Planting Strawberries after Strawberries.

The 1935-6 time of planting experiment has been planned to cover some land that bore strawberries from 1933 to 1935, and some that did not, to give preliminary information on the effect of a previous strawberry crop. (W.S.R. and M.E.R.)

" Burning " in relation to Pest Control.

The practice of " burning " the straw litter directly after picking, which is frequently carried out in commercial strawberry fields, was investigated in 1934, and observations made in that autumn and the following summer disclose that while such pests as the various Strawberry Aphides, Leaf Hoppers, White Fly, and the Strawberry Red Spider

are completely controlled, the Strawberry Tarsonemid Mite is only checked temporarily, and that as soon as the plants produce more new growth, the mites commence breeding again. In 1935 the "burnt" plants were slightly smaller than the unburnt ones, but their crop was more than twice as large. It is doubtful if this result is entirely due to pest control, and it may possibly be connected with delaying of the blossoming so that the severe frost of 16th May harmed the burnt plants less. This work requires repetition in other seasons, and further experiments are being planned.

In autumn 1935 a test was made of a portable motor-operated oil-blowlamp as a field method of "burning" unlittered strawberries. In the forms tested it did not appear to be an economic proposition, on account of the comparatively long time required to dry the green leaves to the burning point. (A.M.M. and W.S.R.)

60. Manuring.

A preliminary trial to study growth and cropping in relation to soil fertility and planting distance has been commenced. Tares have been ploughed in on certain plots to supply humus—in contrast with "no humus" plots. Complete artificials will be applied to certain plots, and three planting distances are being tried under each treatment. On certain plots plants are reserved for digging up for root studies.

Fuller manurial trials in relation to pest and disease attack and soil preparation are being planned. (W.S.R. and M.E.R.)

78. Strawberry Virus Diseases. Yellow-edge and Crinkle.

Field Experiments—Field Diagnosis on variety Royal Sovereign.

A summary of recently available information of aid to growers in the recognition of diseased plants in their runner beds was published (Esf. 27).

Field experiments were commenced in 1935 to determine the possible relation of severity of attack and the appearance, persistence and distinction of symptoms to (*a*) the cultural history of the plant subsequently to infection, (*b*) local fluctuations in weather conditions and (*c*) the general seasonal cycle. These have yielded positive results.

Transmission Experiments with Pot Plants in Greenhouse.

The previously described method by runner-inarching was used throughout the following experiments, with certain modifications.

Determination of Symptoms on Varieties other than Royal Sovereign.

The following were tested: the parent-species of cultivated varieties (*Fragaria chiloensis* and *F. virginiana*), certain cultivated varieties (*Sir Joseph Paxton, Oberschlesien, Tardive de Leopold,* and *Madam Lefebvre*), and a set of seedlings supplied by John Innes Horticultural Institution, derived from a cross between *F. chiloensis* and certain cultivated varieties, and showing marked hardness and vigour and absence of Yellow-edge leaf symptoms. (See also "Breeding" above.)

Possible Alternative Hosts of Yellow-edge Virus.

Infection was attempted of the common wild strawberry (*F. vesca*) and certain species of Potentilla known to be alternative hosts of the common strawberry aphis, a vector of Yellow-edge.

Comparative Studies with other diseases—Strawberry "Crinkle".

An investigation was commenced during 1935 on the identification of possible cases of Crinkle infection in certain collections of seedlings planted out at East Malling and has been conducted in collaboration with the Long Ashton Research Station, whence the first records of the disease for this country came. Plants from the above collection together with type infected material supplied by Long Ashton have formed the basic material for the experiments and the following points have been explored: (i) the possibility of inducing Crinkle symptoms in apparently normal Royal Sovereign plants by runner inarching, (ii) the relation between Crinkle and Yellow-edge and methods for determining whether one or both diseases are present in a given plant.

The results of the above experiments in 1935 indicate that the distribution of Crinkle in the East Malling area is by no means restricted to the above-mentioned seedlings. (R.V.H.)

79. Root Rot of Strawberries.

The investigation has been continued particularly with regard to the relation between root lesions and the normal browning of the cortical tissues. It has been found that this browning often has the appearance of lesions and this accounts for the fact that various fungi, not necessarily parasites, may be isolated from the brown cortex of normal roots. (I.L.T.)

87. The Strawberry Tarsonemid Mite.

Life-Cycle.

A further study of the life-cycle has been made with a view to finding alternative hosts of the mite, and to determine the mode of migration under field conditions.

It has been ascertained that healthy plants may become infested from mite infested plants, if they are planted adjacent to them or at a distance of less than some thirty yards.

Relation to Yellow-edge.

Another detailed experiment has been carried out under natural conditions to determine whether the mite is a possible vector of Yellow-edge. As in all previous experiments of a similar nature negative results have been obtained.

Control.

Warm water treatment. See above under Planting, etc.

Spraying.

A number of insecticides and acaricides have been tested in the laboratory, together with numerous wetting agents with a view to finding a spray which will penetrate the hairy, folded strawberry leaves and destroy the mites.

Preliminary field trials have also been carried out.

Natural Enemies.

A survey of badly infested strawberry fields is being made in the hope of finding insects or mites which are parasitic or predaceous upon the strawberry mite.

(A.M.M.)

89. Strawberry Aphid Investigations.

Studies to determine which months of the year the aphid serves as a vector of Yellow-edge have been started.

A paper (D105), describing the technique used in the strawberry aphid transmission experiments conducted in the field, has been issued.

The original work on the transmission of Yellow-edge by a species of aphid has been repeated and confirmed. Further studies indicate that the aphid is able to transmit the disease during certain months of the year.

Life-cycle, with special reference to Alternative Hosts in the Field.

Observations have been made on the life-cycle of the aphid in field and laboratory, and investigations of some points of the cycle which are not fully understood were continued. A detailed note giving the alternative hosts of the Strawberry Aphid, together with a list of synonyms of the Aphid, has been published (D106).

Control by Sprays and Dusts.

Both laboratory and field experiments have been made upon the strawberry aphid, and it has been found that certain spraying will wipe out the aphid under field conditions. So far the experiments with dusts have given negative results.

(A.M.M.)

90. Insects Feeding upon the Strawberry Plant.

Several insects are being kept under observation and the more promising of these are being tested to ascertain their correlation, if any, with the transmission of Yellow-edge. (A.M.M.)

91. The Warm Water Treatment.

Investigations on improvement of technique are being continued.

(A.M.M. and W.S.R.)

XI. LOGANBERRIES, BLACKBERRIES AND DEWBERRIES

(Combined Pomology and Pathology Investigations.)

43. Classification, Nomenclature and Variety Trials.

The old variety collection of blackberries and dewberries has been grubbed and a new collection planted, including some of the more recent hybrids which will be compared with standard varieties. Parents for clonal races will be chosen from these plants.

A small collection of blackberry seedlings from the John Innes Horticultural Institution have been planted for field trials.

Records are being continued on the collection of Loganberry variants.

(A.B.B.)

53. Propagation.

The clonal stool beds of blackberries and loganberries are now well established, and sufficient plants of several varieties will be available for systematic propagation trials in 1936. (A.B.B.)

58. Planting, Training, etc.

A trial designed to compare the pomological value of loganberry and phenomenal berry and to investigate the possibilities of controlling the cane-spot disease by spraying and/or training was planted with clonal material in March, 1935.

(A.B.B. and R.V.H.)

77. Loganberry Cane-spot.

Spraying Trial.

A further field trial was carried out during 1935 on the efficacy of a single spraying with a combined fungicide and Derris wash applied at the standard time for beetle control. The spraying was carried out by the Insecticides and Fungicides section, the fungicides tested being lime-sulphur and a colloidal-copper compound. The following determinations were made: (i) amount and persistence of spray deposit on berries (see VII, Insecticides and Fungicides), (ii) intensity of fungal spotting on the leaves and the stems of the current year's bines. (R.V.H. and W.S.)

Combined Training and Spraying Trial.

See 58.

86a. Blackberry Mites.

A trial of clonal Himalaya and Black Diamond blackberries has been planted to compare the vigour, cropping and fruit quality of the two varieties and to determine whether a species of Eriophyid mite is associated in any way with a disease of Rubi described in the United States as "Red Berry Disease". A preliminary spraying experiment will also be conducted on the same plants. (A.M.M. and A.B.B.)

Section III

PRELIMINARY RESEARCH REPORTS

POMOLOGY

STUDIES IN INCOMPATIBILITY OF STOCK AND SCION

I. INFORMATION ACCUMULATED DURING TWENTY YEARS OF TESTING FRUIT TREE ROOTSTOCKS WITH VARIOUS SCION VARIETIES AT EAST MALLING

By J. AMOS, T. N. HOBLYN, R. J. GARNER and A. W. WITT

INTRODUCTION.

Ever since the rootstock investigations were started the phenomenon of incompatibility of some of these rootstocks with the scions worked upon them has appeared at more or less frequent intervals. The majority of cases which have been found have been amongst the various forms of Prunus, used as rootstocks for plums and peaches, and the quince (*Cydonia*) stocks when worked with pears. However one or two suspected cases have also been found with apples, and certain layered cherry stocks selected at the Station have been found to be incompatible with various varieties of ornamental cherry.

It is not the purpose of this paper to examine in detail the causes of this uncongeniality between stock and scion or to summarize the numerous literature of the subject. Such a summary has been recently made by the Imperial Bureau of Fruit Production and will shortly be published by them (1). In the present instance the intention is to present in a compact form the information collected at this Station over a period of years; and reference will only be made to publications in which some of this information has already appeared.

The cases which have been experienced here have occurred at all periods in the life of the trees. Most frequently incompatible combinations of stock and scion became obvious in the nursery—buds or grafts either failing to " take " at all, or starting to grow, but dying before the end of the first or during the second season. Quite frequently, however, it was only after some time in the plantation that the phenomenon manifested itself. In some such cases, growth might cease altogether and the tree die or remain stunted indefinitely. In others the defect might betray itself by apparently healthy trees suddenly breaking off at the union when they were even as much as fifteen years old.

Yet again there have been instances of suspected incompatibility in which as yet the only signs of uncongeniality have been reduced vigour and low cropping, together with a bronzing or yellowing of the foliage exceptionally early in the season.

PLUMS.

In the course of the rootstock investigations a wide range of plum stocks has been tested at different times. These have been described (2) and include representatives of at least three distinct species. Thus *Prunus domestica* is represented by the commonly used Brussels and the Yellow Egg or Pershore of Worcestershire ; *P. instititia* by representatives of the Mussel group, Damas and some of the St. Juliens ; *P. cerasifera* by the Myrobolans, and lastly a possible fourth species *P. munsoniana*, which probably includes the Marianna. In addition, there are numerous stocks which, owing to the established practice of using seedling rootstocks, do not fall readily into any specific group.

Cases of incompatibility have been found in all these groups ; and at present there is no reason to suppose that they are any more frequent among stocks falling into one specific group or another.

With regard to the plum varieties used as scions, once again the range includes representatives of all these species ; and while some varieties appear to be definitely more particular than others, there is again apparently no clear cut grouping.

(*a*) *In the Nursery.*

In an early paper (2) there were presented data showing the percentage " take " of buds for a number of stock-scion combinations in the 1919 and 1920 nurseries at the Station. It is now possible to add considerably to the figures given at that time from the history of subsequent nurseries and the whole data now available are summarized in Tables I and II.

The data from original table given in 1921 are included in the two tables now presented, and to both the stocks and scions therein others are added. In particular the seedling Myrobolans then used as stocks, are now represented by the East Malling clonal selection Myrobolan B. Other additional rootstocks are the St. Julien de Toulouse (G) and Kroosgespruim. The performance of other selected Myrobolan, St. Julien and Damas clones will be considered later.

By far the most information available is for the two scion varieties Victoria and Czar, the former a variety which is generally compatible with most stocks and the latter being much more particular. Data are available for budded trees of these two varieties on at least some of the rootstocks studied in thirteen seasons and for grafted trees in three seasons.

In the last three years this information is limited to the two stocks Myrobolan B and Common Plum, which, since 1932, have been included in a special trial designed to show the influence of seasonal conditions on stock-scion compatibility.

It is at once evident that not only are cases of a low percentage " take " much more frequent with the variety Czar as scion, but that upon certain rootstocks poor " takes " are more common than upon others.

In every season good bud " takes " have been obtained for both varieties on Myrobolan B ; and this, with the exception of Pershore and Brompton, for which few detailed records are available, is the only stock to show a uniformly good performance.

Nevertheless it must not be assumed that because a particular combination appears to have given a poor result in one or two seasons, it is necessarily due to incompatibility. The condition of the stocks or scions used in that season may have been in some way unfavourable. Further, in some seasons the " take " is uniformly low, as for example, Victoria budded in 1923.

Table I.

Percentage "Take" of Victoria and Czar on Different Rootstocks.

	Myrobolan Seedlings.	Myrobolan "B."	Pershore.	Brompton.	Common Mussel.	B.L.S. Mussel.	Brussels.	Common Plum.	Marianna.	St. Julien Seedlings.	St. Julien Toulouse G.	Kroosges-pruim.
Victoria.												
Grafted 1919 ..	82	—	100	100	**24**	—	64	**28**	—	66	—	—
Budded 1919 ..	90	—	85	96	58	—	96	75	—	70	—	—
Grafted 1920 ..	—	—	—	—	—	—	—	—	75	—	—	—
Budded 1920 ..	75	—	80	95	**20**	**45**	95	65	**0**	—	—	—
,, 1922 ..	—	84	—	—	59	65	**48**	69	—	—	—	63
,, 1923 ..	—	71	**35**	**34**	**16**	—	**32**	**44**	**34**	—	**15**	—
Grafted 1924 ..	—	90	—	100	96	—	100	100	95	—	100	—
Budded 1924 ..	—	87	—	—	78	86	91	**58**	80	—	90	—
,, 1925 ..	—	—	—	—	**31**	—	—	—	—	—	78	—
,, 1926 ..	—	80	—	—	—	—	90	**52**	—	—	88	—
,, 1928 ..	—	93	—	—	66	—	83	75	88	—	86	—
,, 1930 ..	—	86	—	—	96	—	97	70	77	—	—	—
,, 1931 ..	—	100	—	—	91	—	100	84	94	—	100	—
,, 1932 ..	—	98	—	—	—	—	—	94	—	—	—	—
,, 1933 ..	—	96	—	—	—	—	—	89	—	—	—	—
,, 1934 ..	—	97	—	—	—	—	—	97	—	—	—	—
Czar.												
Budded 1919 ..	90	—	77	90	69	—	**14**	**19**	**5**	55	—	—
Grafted 1920 ..	—	—	—	—	—	—	—	67	76	—	—	—
Budded 1922 ..	—	90	—	—	88	95	**0**	**25**	**50**	—	—	**20**
,, 1923 ..	—	93	**45**	89	76	72	69	81	58	—	61	83
Grafted 1924 ..	—	98	—	100	90	81	97	96	76	—	94	92
Budded 1924 ..	—	91	—	—	94	96	**31**	**30**	**53**	—	**0**	—
,, 1925 ..	—	90	—	—	71	—	**20**	**20**	—	—	**13**	—
,, 1926 ..	—	96	—	—	—	100	**25**	**38**	—	—	—	—
,, 1928 ..	—	82	—	—	59	—	**33**	71	**21**	—	**20**	—
,, 1930 ..	—	97	—	—	71	—	**17**	—	**47**	—	—	—
,, 1931 ..	—	93	—	—	94	—	**48**	**0**	**0**	—	**0**	—
,, 1932 ..	—	95	—	—	—	—	—	**36**	—	—	—	—
,, 1933 ..	—	97	—	—	—	—	—	**37**	—	—	—	—
,, 1934 ..	—	97	—	—	—	—	—	70	—	—	—	—

Table II.

Percentage "Take" of other Varieties on Different Rootstocks.

		Myrobolan Seedlings.	Myrobolan "B."	Pershore.	Brompton.	Common Mussel.	B.L.S. Mussel.	Brussels.	Common Plum.	Marianna.	St. Julien Seedlings.	St. Julien Toulouse G.	Kroosges-pruim.
Giant Prune	*B. 1919	—	—	—	**25**	—	—	70	—	87	93	—	—
,, ,,	B. 1926	—	52	—	—	—	**32**	—	**24**	—	—	72	—
B. de Louvain	B. 1919	83	—	95	89	—	—	—	—	65	—	—	—
,, ,,	B. 1926	—	92	—	—	78	—	—	60	—	—	72	—
Rivers' Early Prolific	B. 1920	95	—	80	100	100	100	90	65	**0**	—	—	—
President	†G. 1920	100	—	96	95	96	95	85	**50**	72	—	—	—
Pershore Egg	B. 1919	80	—	65	100	—	58	**30**	78	80	50	—	—
Purple Egg	B. 1919	—	—	87	71	—	—	**33**	—	—	—	—	—
,, ,,	B. 1923	—	84	—	—	68	—	56	76	56	—	—	—
Denniston's Gage	B. 1919	60	—	**30**	70	—	—	**35**	60	**7**	**45**	—	—
Myrobolan	B. 1919	**30**	—	50	65	**8**	—	**6**	**5**	**0**	**40**	—	—
Pond's Seedling	B. 1926	—	**44**	—	—	**30**	**32**	**28**	**12**	—	—	**32**	—
Monarch	B. 1926	—	92	—	—	**35**	**42**	76	72	—	—	84	—
Utility	B. 1923	—	83	—	—	**10**	—	—	80	90	—	—	—
Prune Damson	B. 1919	85	—	50	**0**	—	—	**5**	**0**	**0**	75	—	—
,, ,,	B. 1921	—	—	—	—	—	—	60	50	—	—	—	—
Black Bullace	B. 1919	30	—	50	65	**8**	—	**6**	**5**	**0**	**40**	—	—
,, ,,	B. 1921	—	—	—	—	—	—	**20**	**20**	—	—	—	—
Cluster Damson	B. 1921	—	—	—	—	—	—	70	80	—	—	—	—
Frogmore	B. 1921	—	—	—	—	—	—	**30**	65	—	—	—	—
Merryweather	B. 1921	—	—	—	—	—	—	**30**	80	—	—	—	—
Shepherd's Bullace	B. 1921	—	—	—	—	—	—	100	85	—	—	—	—
Langley Bullace	B. 1921	—	—	—	—	—	—	81	80	—	—	—	—
Bradley's King	B. 1921	—	—	—	—	—	—	**10**	**15**	—	—	—	—
,, ,,	B. 1923	—	52	—	—	**12**	94	**24**	**0**	**4**	—	—	—
,, ,,	B. 1924	—	95	75	75	80	—	**0**	**0**	**0**	—	—	**0**

* B.=Budded.

† G.=Grafted.

Even so the majority of cases of low " bud take " occur with the same rootstocks. Thus the results for Czar on Brussels, Common Plum, Marianna and St. Julien de Toulouse have been with few exceptions very poor, and though better " takes " have, on the whole, been obtained for Victoria, nine out of the sixteen outstandingly poor results for this variety have occurred on the same four stocks.

Beyond these stocks there is no conclusive evidence of incompatibility at this stage, though the results with Victoria on Common Mussel have been generally poor.

The poor results with Common Mussel are probably not due to stock-scion incompatibility. This stock often becomes dry and difficult to " work " when soil moisture is low, and is further exceptionally liable to attack by red spider (*Oligonychus ulmi* C.L. Koch).

Its susceptibility to this pest undoubtedly intensifies the adverse effect of drought conditions, and has much to do with the many low " takes " associated with this stock.

Table II summarizes the data available for other varieties. These were principally obtained from four nurseries in 1919-20, 1920-1, 1921-2 and 1926-7. In the first the trees for the earliest comprehensive stock trial were raised; eight varieties in addition to Victoria and Czar were included. In the second the Rivers' Early Prolific and President, together with Victoria provided material for the second stock trial. In the 1921-2 series a collection of damsons was worked mostly on two stocks. Finally four varieties were included in a series budded in 1926.

Once again the majority of the failures are on the same four rootstocks; 30 out of 47 " takes " of less than 50 per cent. occurring among them. On no other clonal stock, with the exception of Common Mussel, has the " take " been so consistently low. The number of " buddings " is insufficient to draw any conclusion as to the qualities of different varieties, except in so far as the damson varieties have as a whole failed upon Brussels and Common Plum. In view of subsequent events in the field the good " take " of the grafted Presidents on all stocks is worth comment.

Up to the present attention has been confined to the first year in the nursery. Table III shows the nursery history for the first two years of Victoria and Czar budded and grafted on some of these stocks in 1923 and '24.

The percentage " takes " have already been shown in Table I. With the grafted trees these were all high, but for the budded trees the season was a poor one for Victoria though most of the Czar buds started to grow.

By the end of the first season, however, the position was considerably altered. With very few exceptions all the trees of Victoria which " took " were alive at the end of both the first and second years. With Czar, however, incompatibilities, which had not shown up early in the first year, were evident later on, both for budded and grafted trees. By the end of the second year there had been a heavy loss of trees on Brussels, Marianna, Kroosgespruim and St. Julien de Toulouse. It is interesting to note, however, that few trees of Czar on Common Plum, usually a poor combination, were lost in this season, and that those which were subsequently planted out in the field in the winter 1925-6 were all alive, though dwarfed, in 1936.

This is but one instance of an apparently high " take " of buds failing to produce one- or two-year-old trees. Thus several of the good results shown on incompatible stocks in Tables I and II were not maintained for long. In particular the whole of the damsons on Brussels and Common Plum were dead or broken out at the union by the end of the second year.

This particular aspect of the incompatibility problem will be even more clearly shown when the growth of certain pears on quince stocks is discussed.

Table III.

Two Years' Nursery History of Victoria and Czar.

(Budded in July, 1923 and Grafted in March, 1924.)

Victoria.

On Stock.	Buds.			Grafts.		
	% "Take."	% One Year Old Trees.	% Two Year Old Trees.	% "Take."	% One Year Old Trees.	% Two Year Old Trees.
Myrobolan B.	76	76	76	90	90	88
Common Plum	**44**	42	42	100	96	96
Brussels	**32***	34	34	100	100	100
Marianna	**34***	40	38	95	92	90
Kroosgespruim	—	—	—	—	—	—
St. Julien G.	**15**	15	15	100	98	96

* A few buds started late in the season.

Czar.

On Stock.	Buds.			Grafts.		
	% "Take."	% One Year Old Trees.	% Two Year Old Trees.	% "Take."	% One Year Old Trees.	% Two Year Old Trees.
Myrobolan B.	93	78	78	98	96	87
Common Plum	81	80	70	96	90	78
Brussels	69	61	**37**	97	**41**	**26**
Marianna	**58**	**47**	**41**	76	**49**	**49**
Kroosgespruim	83	**30**	**13**	92	**56**	**51**
St. Julien G.	61	**36**	**15**	94	**34**	**16**

The story of trees worked upon the Myrobolan and St. Julien seedlings is somewhat variable, both good and bad "takes" being obtained. From these seedling collections certain members were selected for clonal propagation and the results obtained in working these selections have also been variable. One (D) out of five clonal Myrobolans has shown a tendency to incompatibility in the nursery and although Czar grew satisfactorily on most of the St. Julien and Damas selections, great differences were shown when these selections were used as stocks for peaches.

It should be noted that the St. Julien de Toulouse, mentioned in these tables, is a layered stock which has been for some time in fairly wide commercial circulation in Europe, and is not one of the clonal St. Juliens selected at East Malling.

(*b*) *In the Plantation.*

The behaviour of the plum stock-scion combinations in the nursery having been reviewed, it remains to show how these rootstocks and scions, some of which exhibited such pronounced partialities in the early years, behaved when planted out as permanent trees.

In certain cases it is evident that insufficient trees survived the nursery period, so that few trees were available for planting. For the same reason no trees were planted

out on St. Julien de Toulouse. However, with this exception, some trees of all combinations detailed above were planted out in the Station's plum rootstock trials. The subsequent performance of the more important sets is briefly summarized in Table IV for four stocks liable to incompatibility. These are Brussels, Common Plum, Marianna and Broad-leaved Shiny Mussel, and they are compared with Myrobolan B and Common Mussel. It is not proposed to go into their history in detail; for this the reader must be referred to the reports on the plum rootstock trials, the latest of which is now in the press (3, 4). The varieties examined here include four plantings of Victoria and Czar, and one planting each of President, Early Rivers, Purple Egg and Utility.

The history of most of these trees from the time they were planted has been seriously complicated by disease. In the earlier years of these experiments, many trees were affected either by silver leaf (*Stereum purpureum*) or bacterial dieback (*Pseudomonas mors-prunorum*). In particular the first two plantings of Victoria and the first of Czar suffered from an epidemic of silver leaf, while all subsequent plantings of these two varieties were affected by bacterial dieback to a greater or lesser extent. Few trees of the other four varieties here presented were affected by either of these diseases. In consequence it is not always easy to diagnose, when a tree died, the reason for its death. In some cases incompatibility was the obvious cause—the tree breaking off at the union. In others, however, there was no clear reason, and as there was no evidence of disease, the tree was presumed to be an incompatible. It is of course possible that some of the diseased trees also suffered from incompatibility. Apart from disease, the combinations where the most deaths occurred were Czar on Brussels and Marianna and President on Brussels and Common Plum. In two successive plantings of Czar on Brussels 20 and 27 per cent. of the trees succumbed, while in the only planting of Czar on Marianna 25 per cent. died.

Of the trees of President on Brussels and Common Plum, 64 and 62 per cent. had died by the time the trees were 14 years old. Thus, of the eleven trees of President on Brussels, planted out as two-year-olds in 1922, five were dead by 1927, one died in 1929 and another broke off at the union in 1935. Eight Presidents on Common Plum were planted, two of which died after four years, one a year later and two after a further two years. Of all the 500 trees of Victoria planted at the Station since 1920, only two deaths unconnected with disease have occurred. Of these one on Myrobolan was possibly due to dieback, though this was not certain, and the other on Broad-leaved Shiny Mussel broke off at the union during a gale in its fifteenth year. It is interesting to note that two trees, one of Pershore Egg and the other Prune Damson, on this stock, not included here, were " blown out " in a similar way. For the rest, one tree out of a set of ten of Czar on Common Mussel died for some unexplained reason and one tree out of eight of President on Marianna died in its eighth year.

The performance of the surviving trees on these stocks is indicated by the Trunk Thickness (area of stem cross-section in sq. cm.) which gives a good comparative measure of vigour, and Total Crop per tree in kilograms up to the present time or up to the time when the experiment was discontinued. This aspect is more fully dealt with elsewhere (4), but certain points may be briefly indicated here. Compared with trees on other stocks those on Brussels are uniformly small and poor cropping. While the trees of Czar on Common Plum have not died, they are stunted and unthrifty; on the other hand Victoria, Early Rivers and Purple Egg have made small but healthy trees on this stock, and they have cropped well for their size. While it shows no sign of incompatibility in the plantation, Common Mussel is evidently a stock which gives mediocre trees. Where it is safe to use Marianna, the potentialities of the stock for heavy cropping, as shown by results up to date, make it worthy of further trial.

Table IV.

After History of Trees on Incompatible Stocks in the Field compared with Myrobolan.

On Stock	Myrobolan.				Brussels.				Common Plum.			
Variety.	% Diseased.	% Died Incompatible.	Trunk Thickness sq. cm.	Crop. Kg.	% Diseased.	% Died Incompatible.	Trunk Thickness sq. cm.	Crop. Kg.	% Diseased.	% Died Incompatible.	Trunk Thickness. sq. cm.	Crop. Kg.
10 year-old Victoria. Plot 15 ..	29*	—	71*	136*	43	—	47	93	17	—	47	194
13 year-old Victoria. Plot 20 ..	87*	—	147*	122*	69	—	95	68	100	—	85	85
14 year-old Victoria. Plot 21 ..	33†	—	184†	206†	50	—	122	118	55	—	97	115
9 year-old Victoria. Plot C4 ..	20†	10	78†	16†	—	—	—	—	—	—	50	17
13 year-old Czar. Plot 20 ..	93*	—	141*	110*	67	—	82	—‡	67	—	48	45
14 year-old Czar. Plot 21 ..	20†	—	138†	291†	—	**20**	67	100	—	—	—	—
11 year-old Czar. Plot 29 ..	25†	—	91†	92†	18	**27**	51	52	—	—	41	51
9 year-old Czar. Plot C4 ..	10†	—	73†	32†	—	—	—	—	—	—	—	—
14 year-old President. Plot 21 ..	8†	—	330†	130†	9	**64**	128	45	—	**62**	160	91
14 year-old Early Rivers. Plot 21	—	—	143†	121†	—	—	92	50	—	—	95	81
11 year-old Purple Egg. Plot 29	—	—	114†	123†	—	—	65	61	—	—	56	88
11 year-old Utility. Plot 29 ..	—	—	244†	19†	—	—	—	—	—	—	146	20

On Stock	Common Mussel.				B.L. Mussel.				Marianna.			
Variety.	% Diseased.	% Died Incompatible.	Trunk Thickness sq. cm.	Crop Kg.	% Diseased.	% Died Incompatible.	Trunk Thickness sq. cm.	Crop Kg.	% Diseased.	% Died Incompatible.	Trunk Thickness sq. cm.	Crop. Kg.
10 year-old Victoria. Plot 15 ..	33	—	—	182	—	—	—	—	—	—	—	—
13 year-old Victoria. Plot 20 ..	87	—	80	60	—	—	—	—	—	—	—	—
14 year-old Victoria. Plot 21 ..	45	—	101	112	30	**10**	86	107	47	—	115	241
9 year-old Victoria. Plot C4 ..	12	—	51	22	—	—	—	—	—	—	—	—
13 year-old Czar. Plot 20 ..	78	—	82	79	—	—	—	—	—	—	—	—
14 year-old Czar. Plot 21 ..	—	—	—	—	—	—	—	—	—	—	—	—
11 year-old Czar. Plot 29 ..	—	—	70	67	—	—	71	73	25	**25**	63	84
9 year-old Czar. Plot C4 ..	10	10	41	15	—	—	—	—	—	—	—	—
14 year-old President. Plot 21 ..	—	—	200	74	—	—	260	88	—	**12**	245	122
14 year-old Early Rivers. Plot 21	—	—	90	77	—	—	118	106	10	—	129	119
11 year-old Purple Egg. Plot 29	—	—	70	74	—	—	—	—	—	—	58	90
11 year-old Utility. Plot 29 ..	—	—	—	—	—	—	—	—	—	—	139	14

* Seedling Myrobolan. † Myrobolan B. (Clonal). ‡ Crop Record Incomplete.

There are no further evidences of incompatibility in other plum stock trials at the Station. As has been already pointed out, no damsons survived more than two years on Brussels, Common Plum, St. Julien de Toulouse and Marianna, but on other rootstocks they have grown well. Few other varieties on Brussels have been planted, but such varieties as Cambridge Gage, Yellow Egg, Bastard Victoria, Belle de Louvain, Denniston's Superb, Giant Prune have succeeded, though dwarfed on Common Plum.

In November, 1925 a few layered stocks of each of five selections of *Prunus pumila* were received from the late Mr. E. G. Hunt, of Barnstaple, Devon, and a year later a collection of varieties (mostly Gages) worked upon three of these selections was received from the same source.

After a year in the nursery three of the selections were budded with Denniston's Superb Gage. Very poor "takes", however, were obtained on all three selections, the few trees which resulted being in all cases too weak to be of any value.

The varieties on these selections received in 1926, were planted as cordons and the trees were found to be in all cases very dwarf and quick cropping, but very weak at the union, where there was a pronounced bulge. The series was lifted in 1931, by which time the majority were so stunted as to be of little value, some having already died.

PEACHES.

In this country peaches are commonly worked upon certain plum rootstocks, particularly the Mussels, Brompton and seedling St. Julien and Damas stocks. As has been pointed out (2), the nomenclature of these stocks was very uncertain and much confusion existed; therefore nursery trials of peaches worked upon those plum stocks in common usage, collected at this Station, were commenced in 1921. Since that date most of these stocks have been budded with Hale's Early Peach in three or more seasons. In one season two further varieties, Peregrine and Amsden's June, were tried upon eleven stocks, but the numbers under trial were insufficient to justify any conclusion. In general the experiments have been confined to the one standard variety.

Two years later seven selected clonal St. Julien and Damas stocks were added; and these have been frequently tried in the nursery since. To these one further St. Julien selection was added in 1930.

The nursery results of budding these peaches are very clear cut as is shown in Tables V and VI. Part of these figures have already been published (5), and they are now brought up to date. Of the plum stocks in common circulation, Brussels and Common Plum have always failed completely, as has also the East Malling selected Myrobolan B. Although the buds often start to grow they are invariably dead by the end of the season. This is the only Myrobolan selection which has been tried with peaches at this Station until the present season, with the exception of the Violet Myrobolan upon which good one-year-old trees were obtained in 1929. In the present season a series of selections of *P. cerasifera*, said to be unusually receptive to peaches budded or grafted upon them, have been received from Professor Howard of the University of California and are under trial; and it is of interest to note that workers at that Station have found all ranges of compatibility and incompatibility amongst seedlings of this species (6).

On the other hand Brompton, the three Mussels, Pershore, Marianna, Kroosgespruim and St. Julien de Toulouse always give a good proportion of one-year-old trees.

The differences in performance of the clonal St. Julien and Damas stocks with Hale's Early in the first year are equally decided. Of the five St. Julien stocks, two have

Table V.

Percentage of One-year-old Trees Produced. Hale's Early Peach on Rootstocks in Common Usage.

Year of Budding.	Myrobolan B.	Pershore.	Brussels.	Brompton.	Common Mussel.	B.L. Mussel.	N.L. Mussel.	Common Plum.	Marianna.	Kroosgesp.	St. Julien de Toulouse.
1921	—	46	0	—	80	21*	71	0	33	61	—
1922	70§	33	30§	80	60	95	—	95§	55	71	—
1923	—	—	—	—	—	—	—	—	—	—	61
1924	50§	77	—	73	74	57	57	15§	—	85	80
1925	—	—	—	—	—	—	—	—	—	—	70
1928	—	57	—	—	81	—	—	—	67	—	55
1930	—	47	—	60	33	61	—	—	51	—	—
1931	—	50	—	100	53	76	—	—	66	—	—

* Dry Stocks. § All died before they were two years old.

never produced any trees for planting out, while the other three have always given good results. Likewise one out of the three Damas stocks has invariably failed.

Trees from the 1924-5 nursery were planted out as one-year-olds in winter 1925-6 and trained as fan trees in the open, until the end of 1929. The trees were then lifted and some of them transplanted to a permanent position against a board fence. The history of these trees (5) shows that the symptoms of incompatibility may be delayed with peaches as with plums. Of the six trees on St. Julien de Toulouse four died during the first year. One tree out of six on Narrow-leaved Shiny Mussel died in the second year and one tree out of eight on Broad-leaved Shiny Mussel in the fourth.

TABLE VI.

PERCENTAGE ONE-YEAR-OLD TREES PRODUCED. HALE'S EARLY PEACH ON CLONAL ST. JULIEN AND DAMAS STOCKS.

Year of Budding.	St. Julien.					Damas.		
	A.	B.	C.	D.	K.	A.	C.	D.
1923	61	31	100	25§	—	60§	10*	70
1924	77	86	100	95§	—	100§	96	73
1925	—	—	—	—	—	36§	95	—
1928	86	81	64	14§	—	0	67	100
1930	58	29	55	30§	5§	3§	70	—
1931	88	67	82	10§	9§	—	69	—
1932	82	45	70	0	—	—	—	—
1933	78	—	86	—	0	—	—	—
1934	86	—	79	—	0	—	—	—

* Dry Stocks. § All died by the end of the season.

When the trees were lifted the second time, those on St. Julien B were noted as being very poorly rooted, and of the six of them which were replanted, five failed to survive the first year. One tree on St. Julien C also died. Of the remainder one tree each on Brompton, Pershore, Damas C and D have since been lost, but it is improbable that these losses were due to incompatibility.

Peaches as rootstocks have not until recently received much attention at this Station, though a few seedling peach stocks, budded with Hale's Early in 1928, produced some one-year-old trees.

Six peach stocks, selected from some hundreds raised from seed received from France in 1928, have been since subjected to layering tests and rooted layers from these were budded with Hale's Early in the present season (1935) for the first time.

CHERRIES.

Among the numerous Mazzard and Mahaleb stocks for cherries selected and propagated vegetatively at this Station, no definite case of incompatibility has occurred with any of the sweet or acid cherries worked upon them. A number of sweet cherry varieties have been worked on the various Mazzard selections and four acid cherry varieties have been tried with both selections of Mazzard and Mahaleb. The only possible uncongenial combination among these was Morello on certain Mahaleb selections. These trees, after some years heavy cropping, have lost their early vigour and in three out of eighteen cases died by the time they were nine or ten years old.

On the other hand, when in 1934 six varieties of ornamental cherries were budded to two Mazzard and five Mahaleb selections, definite incompatibilities were found. While all the trees on Mazzard grew vigorously, all but two of the series on Mahaleb failed altogether. Upon one selection the buds started into growth, but failed to make one-year-old trees. Upon the other selection weak one-year-old trees were achieved, but as in the case of peaches all died by the end of the season.

In 1928 a few Morello buds were worked upon three selections of *Prunus tomentosa* (a very dwarf species), but without exception these failed to make any growth. This species of Prunus is used in China as a stock for the Chinese early cherry, *P. pseudocerasus*. Finally on two occasions Morello scions have been budded on a layered selection of *Prunus padus*, but proved quite incompatible.

Pears.

The rootstocks commonly used for pears were the quince and seedling pear. The former, three varieties of which were usually employed, was supposed to give dwarf trees, and the latter (probably *Pyrus communis*) was used to make vigorous, long-lived standard trees.

Nurserymen and growers have long been aware of incompatibility between certain varieties of pear and the quince stocks on which they were worked, and it was common practice to work certain varieties, such as Souvenir de Congres, over an intermediate variety, as they were known not to grow well on quince.

Accordingly with the object of finding dwarfing rootstocks of wider applicability, when the pear rootstock studies were commenced, to the varieties then in common use, such as Angers, Common and de Fontenay (East Malling A, B and D) and an unnamed variety (C), were added certain of the stronger growing quinces such as the Apple-shaped (F), Pear-shaped (G) and Portugal (E), although the latter were not then in common use as rootstocks. Further, clonal races of pear stocks were raised from a collection of wild and " free " pear seedlings, in the hope that some of them would prove of a dwarfing nature.

(*a*) *Quince Rootstocks.*

The results obtained in the trials of a number of varieties on the different quince stocks have already been described (7, 8) and it is only necessary to summarize them here.

Table VII.

Percentage Bud " Take " of Five Varieties on Quince Stocks.
(Budded 1922.)

On Quince.	A.	B.	C.	D.	E.	F.	G.
Conference	95	93	95	53	58	90	83
Fertility	98	98	95	75	80	95	100
Emile d'Heyst	93	98	75	45	67	88	88
Dr. Jules Guyot	95	85	90	43	63	63	55
Durondeau	93	95	93	38	37	78	68

The story here is generally one of delayed incompatibility rather than an immediate failure in the first year after budding. In 1922 the seven quinces in the original collection were budded with each of five varieties, Conference, Fertility, Emile d'Heyst,

Dr. Jules Guyot and Durondeau, forty stocks being worked in each case. As is shown in Table VII, with few exceptions a good percentage of one-year-old trees resulted. While Quinces A, B and C gave very good "takes" for all varieties, the result was generally less good on D and E. Two varieties were rather poor on Quinces F and G. This, however, is not quite the whole story, as certain varieties particularly with Dr. Jules Guyot and Durondeau gave much smaller one-year-old trees on Quinces D-G than upon A, B and C.

Table VIII.

Percentage of One-year-old Trees of Conference, Pitmaston and Durondeau on Quince.

Year.	A.			D.			E.			F.			G.		
	Con.	Pit.	Dur.	Con.	Pit.	Dur.	Con.	Pit.	Dur.	Con.	Pit.	Dur.	Con.	Pit.	Dur.
1928	84	89	89	100	—	—	100	79	93	—	—	—	95	89	79
1930	93	93	96	89	100	75	100	78	100	—	—	—	94	100	88
1931	92	96	92	94	88	27	53	35	6	86	5	0	89	0	5
1932	91	90	91	—	—	—	—	—	—	—	—	—	84	94	81
1933	92	98	95	—	—	—	—	—	—	97	87	100	—	—	—
1934	97	80	92	—	—	—	—	—	—	100	100	90	—	—	—

Table IX.

Average Maiden (one-year-old). Height in cm. of Conference, Pitmaston and Durondeau on Quince.

Year.	A.			D.			E.			F.			G.		
	Con.	Pit.	Dur.	Con.	Pit.	Dur.	Con.	Pit.	Dur.	Con.	Pit.	Dur.	Con.	Pit.	Dur.
1928	88	97	85	75	—	—	67	52	94	—	—	—	89	65	65
1930	86	57	90	89	71	32	84	68	56	—	—	—	88	100	58
1931	83	83	116	96	40	41	77	35	33	75	29	0	80	0	29
1932	104	106	114	—	—	—	—	—	—	—	—	—	90	75	62
1933	89	86	107	—	—	—	—	—	—	96	67	93	—	—	—
1934	102	88	112	—	—	—	—	—	—	106	115	90	—	—	—

These preliminary nursery results were confirmed by those obtained more recently. These are summarized for three varieties (Conference, Pitmaston and Durondeau) in six seasons in Tables VIII and IX. There has been little to choose between Quinces A, B and C, all of which have given excellent results, and accordingly Quinces B and C are omitted in these tables. With the exception of the year 1931, Quinces D, E, F and G gave a high percentage success in the years they were included. The year 1931 was evidently exceptional and it is difficult to explain the early failure on these four stocks which was most marked with Pitmaston and Durondeau.

Once again, however, as shown in Table IX Durondeau always made smaller one-year-old trees on these stocks; the Pitmaston Duchess trees were also small in several seasons.

Where the trees have been allowed to stand in the nursery row for a second season, those on D, E, F and G have usually grown poorly and often a high mortality has taken

place. For example all the trees of Pitmaston Duchess which were budded on Quince F in 1933 died during 1935.

In the quince rootstock trials which have been subsequently planted out numerous attempts have been made to grow trees upon these four stocks; but whereas trees on Quinces A, B, and C have always succeeded, except with such varieties as Dr. Jules Guyot, the history of the others has nearly always been one of stunted growth or early death. This has only been modified when the scion variety has established itself upon its own roots.

TABLE X.

SUBSEQUENT HISTORY IN THE FIELD OF CONFERENCE (SIXTEEN-YEAR-OLD AND FOURTEEN-YEAR-OLD) AND FERTILITY (TEN-YEAR-OLD) ON QUINCE STOCKS.

On Quince.	Variety and Year of Planting.								
	Conference. (1921)			Conference. (1923)			Fertility.* (1923)		
	Normal.	Stunted.	Dead.	Normal.	Stunted.	Dead.	Normal.	Stunted.	Dead.
A.	12	4	0	16	0	0	20	0	0
B.	16	0	0	16	0	0	20	0	0
C.	16	0	0	16	0	0	19	0	1
D.	2	5	9	8	6	2	5	14	1
E.	—	—	—	11	4	1	1	7	12
F.	0	0	16	11	5	0	0	4	16
G.	0	0	16	16	0	0	0	3	17

* Experiment concluded in 1932.

There have been, however, certain exceptions as Table X clearly shows. This table gives the history in the plantation of three trials, two of Conference planted in February, 1921 and January, 1923 respectively, and still under experiment, and one of Fertility planted in November, 1923, and concluded in 1932.

In the first series of Conference out of sixteen trees planted on each stock all the trees on F and thirteen trees on G had died by the end of the second year. Three trees had also died on D. During the next six years two more trees on G and four trees on D died. The remaining tree on G and two more on D died subsequently.

For the rest, four trees on A are rather stunted, as are also to a much greater degree five of those on D.

In the second planting of Conference events have been somewhat different. There, the trees have been variable on D, E and F, but all the sixteen on G are apparently healthy trees in 1936. This is not due to scion rooting; indeed Conference has never been known to scion-root at this Station.

The history of the series of Fertility is much the same as that of the first planting of Conference. Most of the trees on E, F and G did not survive long, while the majority on D were stunted when the experiment was discontinued in 1932. Of the surviving trees, those on D and E certainly owed their vigour to scion rooting, since in most cases the quince roots were dead or very small. This variety has proved very prone to this habit, for many of the trees on A, B and C proved also to have rooted from the scion when they were lifted, though in these cases the pear roots were still subsidiary to the quince.

Five further experiments with Durondeau, Emile d'Heyst and Dr. Jules Guyot, Pitmaston Duchess and Doyenne du Comice on the whole range of quince stocks previously mentioned have also been planted. The failure of these four Quince stocks has been practically complete in every series, whereas quinces A, B and C have been generally successful, except with the variety Dr. Jules Guyot as already mentioned. Where trees on Quinces D, E, F and G have not died, they have been extremely stunted, unless scion rooting has taken place.

Three further varieties of quince, Champion and Meech's Prolific, both large fruited types, and an unnamed variety called East Malling C1, have been tested with Dr. Jules Guyot and Reine des Poires, with the object of finding a quince stock which would be of value for these two difficult varieties. However, they proved no better than Angers, indeed as a rule they produced more dwarfed trees, a larger proportion of which died.

(*b*) *Pear Stocks.*

Those "Free" Pear stocks, selected at this Station, which survived a vigorous propagation test, were budded with Dr. Jules Guyot and Reine des Poires in 1923.

During their subsequent trial in the nursery a wide range of vigour was found to exist (9). Although all the selections included gave good trees in the first year, two out of eighteen did not survive the three years in the nursery. The growth during this period of Dr. Jules Guyot on five of the selections is demonstrated in Fig. 1. Of these A2 was the smallest from the first and made no further growth after the second year. The other (C3), which failed in this test, started off much more vigorously, but after that fell off very markedly in growth and was discarded at the end of the third year.

Two large scale field trials from this nursery, one of standard trees and one of bush, were planted out in the winter 1926-7. These included trees on all the stocks in the nursery trial except those mentioned above ; those which were not vigorous enough to make standards were grown only as bush trees. All the trees then planted were alive at the end of 1935, though marked differences in vigour were apparent. One, however, A3, has for some years shown symptoms which suggest delayed incompatibility. The trees of both Dr. Jules Guyot and Reine des Poires are small though not actually stunted, and the foliage annually turns a vivid copper beech colour in the autumn, while trees on other stocks are still dark green.

(*c*) *Other Stocks Tested for Pears.*

In the search for other rootstocks for pears, a trial was started in 1919 in which various forms of Pyrus, Cydonia and Crataegus, were included. In this early experiment Fertility was grafted on Wild Pear (*P. communis*), Angers (A), and Portugal (E) Quince, Mountain Ash (*P. Aucuparia*), Wild Service (*P. Sorbus domestica*), White Beam (*P. Aria*) and Hawthorn (*C. Oxyacantha*). All except the quinces were of seedling origin. On all these diverse stocks excellent one-year-old trees were produced, and ten trees of each were planted out in 1920. These were all lifted and an examination of the root-systems made in January, 1929. Up to that time, trees on Wild Pear and Hawthorn had made exceptionally vigorous growth. The trees on both quinces made moderate growth, but five on Angers died in the early years. This was probably due to some cause other than stock-scion incompatibility, for it will be remembered the Fertility on Angers did well in a later trial referred to above. On the other three stocks growth was stunted ; but where Service and White Beam were the rootstocks scion rooting had commenced when the experiment was concluded.

In addition to the above experiment certain other species of Pyrus have been tested from time to time. These comprised a few layered selections of *P. serrulata*, *P. calleryana* and *P. serotina* worked with Dr. Jules Guyot. No sign of incompatibility has been seen at present, the trees on the two former at six years old behaving very similarly to those on the stronger pear stocks.

Three further selections of Hawthorn also have been tested in the nursery with Dr. Jules Guyot and Reine des Poires. A certain number of small one-year-old trees

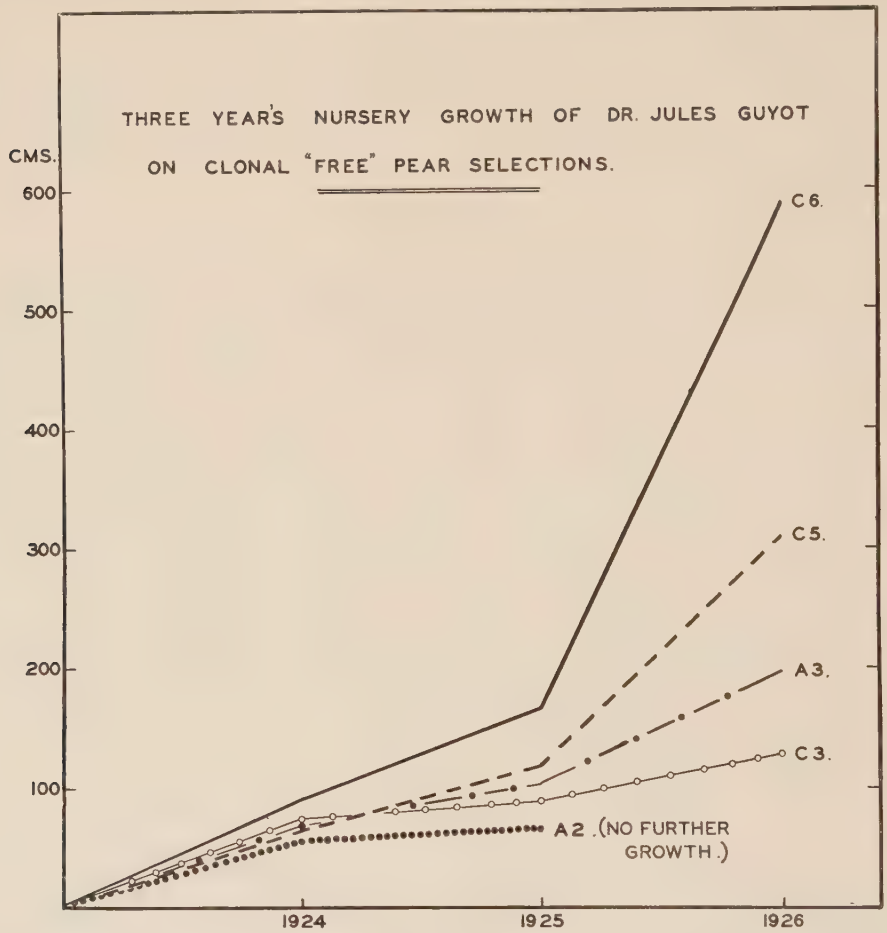

FIG. 1.

with Dr. Jules Guyot as scion were obtained, but all with Reine des Poires were completely incompatible.

APPLES.

In all the apple rootstock investigations at this Station no case of complete incompatibility has been found; indeed in the nursery there has been no evidence at all to suggest that it exists.

In all the "Paradise" and "Free" stocks selected here, no instance of incompatibility comparable with that found in plums, pears and cherries has occurred. It is

true that some of these stocks produce dwarf trees, as for example Malling Nos. VIII and IX, but whether this healthy dwarfingness, which is combined with early precocity and heavy cropping, is another form of incompatibility is at present a matter for speculation. Trees on No. IX have certainly been known to break at the union, but on the other hand, this breakage is just as likely to occur in the stock itself below the union. The roots of this stock are well known to be brittle. The presence of a prominent bulge above the union cannot be cited as evidence, since in most of the unmistakably incompatible combinations found here, the bulge is entirely absent. One or two other apparently uncongenial combinations have been noted, for example Bramley's Seedling on No. X (10), which tends to make sparse growth and to crop poorly, but at sixteen years old there is still no sign of stunting or premature decease.

On the other hand, in a series of layered free stocks received from Long Ashton Research Station, which were budded with Lane's Prince Albert and planted out in March, 1927, two of thirteen selections seem more likely to be at least semi-incompatible with this scion variety. Amongst these stocks a wide range of vigour has been found to exist and at least three selections are definitely dwarfing. Of these, two show signs of incompatibility being comparatively unproductive, and tending to show a bronzing and purpling of the leaves in early autumn. Further, the bark of these trees presents an unhealthy cracked appearance. These again, however, show no signs of dying at ten years old.

In a preliminary account of the performance of this series of stocks, Spinks has noted the irregular performance of trees on one of the two stocks here referred to in the trial at Long Ashton (11). In correspondence recently, he has informed the writers that evidences of incompatibility have been recorded upon both stocks with several varieties, in one combination some trees having even died.

The results are, however, rather variable, one or two varieties showing no signs of the trouble, and the same variety behaving differently under varying soil conditions.

This evidence suggests that among the many thousand seedling stocks, which have been, and still are, used for apples, a proportion may be incompatible ; and this may account for some of the unhealthy dwarfed trees which are sometimes found among apple trees so raised.

Until the causes of incompatibility are established, there is no means of telling whether these milder symptoms are a form of the trouble or yet another manifestation of rootstock effect.

Acknowledgments.

In order to compile the foregoing paper, which is a summary of observations made since the Station's inception, the work of many individual members of the Pomology Staff has been freely drawn upon. The authors therefore gladly acknowledge their indebtedness to them. They also have particularly to thank Miss J. L. Edgar for much painstaking work in collecting the material from the Station's records from which the tables have been prepared.

Summary.

Instances of stock-scion incompatibility which have occurred at East Malling in the course of the Station's Rootstock investigations are summarized.

1. Of the stocks for *Plums* in common usage Brussels, Common Plum, Marianna, Kroosgespruim and St. Julien de Toulouse have been found to be more or less incompatible with a number of varieties—in particular Czar, President and the Damsons. Poor

" takes " of buds are usually obtained, or death may take place either in the first or second year in the nursery or subsequently in the field. Cases of incompatibility with Victoria, Purple Egg and Rivers' Early Prolific have been rare.

Different results have been obtained with selected Myrobolan, St. Julien and Damas clones used as rootstocks in the nursery, but no cases of delayed incompatibility with plums have been found.

Of these rootstocks Common Plum and Marianna may be of value for varieties with which they are compatible, but Brussels always gives poor results.

2. Hale's Early *Peach* has been found to be quite incompatible with Myrobolan B, Brussels and Common Plum, and though St. Julien de Toulouse gave good nursery trees there was a high mortality later. Some selected St. Julien and Damas clones have proved valuable for peaches, but others have failed absolutely either in the nursery or after a few years.

3. With the exception of certain ornamental varieties with Mahaleb, and Morello budded on selections of *Prunus tomentosa* and *Prunus Padus* no definite cases of incompatibility in *Cherries* have been found.

4. While good " takes " have been generally obtained in the first year, with *Pears* worked upon seven varieties of *Quince*, the de Fontenay and three other stronger growing quinces have proved incompatible with most varieties, the trees becoming stunted either in the second season or subsequently, and generally dying early, unless scion rooting has occurred in the meantime.

On one or two occasions, however, good trees on these stocks have resulted from a particular season's budding.

Of eighteen clonal " *Free* " *pear* stocks selected at East Malling, and budded with Dr. Jules Guyot, two have proved incompatible before they were three years old, while one has shown signs of semi-incompatibility at a later stage in the field.

Of other forms of *Pyrus* and *Crataegus*, grafted with Fertility, Mountain Ash, Wild Service and White Beam made stunted trees ; those on Hawthorn were vigorous, as were also Dr. Jules on layered selections of *P. calleryana* and *P. serotina*.

5. No absolutely incompatible combination has been found in all the *Apple* stock-scion investigations ; but two out of thirteen layered " free " stocks received from Long Ashton Research Station have showed signs of semi-incompatibility when worked with Lane's Prince Albert.

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A PRELIMINARY REPORT ON THE INTERNAL STRUCTURE OF THE WOOD OF No. IX ROOTSTOCK IN RELATION TO SCION-ROOTING OF APPLES

By A. B. BEAKBANE and M. E. RENWICK.

TWENTY-FIVE eight- to ten-year-old cordon apple trees on No. IX rootstock, grown at the South-Eastern Agricultural College, Wye, Kent, were grubbed in October, 1935. The trees were raised by grafting the scion variety on to the stem of established rootstocks, thus following the practice normally carried out in the fruit tree nurseries in this country. Many of the trees appeared to be scion-rooted, and it was often difficult to make a definite decision, from the external appearance, as to whether they were really scion-rooted or not. Mr. R. T. Pearl kindly offered material from these trees for anatomical examination, in order to find out whether it was possible to distinguish between scion roots and No. IX roots from their internal structure and so to ascertain which trees were scion-rooted. Pieces of root several inches long were removed from the trees and brought to East Malling, where transverse sections of the fresh material were cut from the No. IX rootstock of each tree and also from scion roots, or possible scion roots, where these were present. The sections were stained with safranin and light green and mounted in Canada balsam.

A preliminary examination showed that one of the most striking differences between the No. IX roots and scion roots was in the size of the vessels. The No. IX roots had remarkably small vessels, whereas those of most of the scion roots were much larger. There also appeared to be a certain amount of variation in size of vessels between the No. IX roots grafted with different scion varieties. Detailed measurements of the long and short diameters of vessels, chosen from a band of xylem between 200 and 400μ from the cambium, were taken by means of an eye-piece micrometer. A number of " fields " were chosen at random all round the section, until thirty vessels were measured. (See Table I.)

There were fourteen trees in which it was possible to compare the structure of a scion root with that of a No. IX root on the same tree. In eleven varieties the vessels, as seen in transverse section, were larger than, and in two varieties (Lady Sudeley and Feltham Beauty) approximately equal to, those of the No. IX roots, while the vessels of the Rival scion root were actually slightly smaller than those of the No. IX. There appears to be no correlation between the size of the vessels in scion roots and in No. IX roots of the same tree. For of the No. IX roots with vessels above the average size three were from trees grafted with scion varieties having roots with small vessels and two with varieties bearing roots with large vessels. On the other hand of the trees from which the No. IX roots with vessels below the average size were taken, four were grafted with scions having roots with large vessels and two with scions having roots with small vessels. In the remaining three trees, where the size of vessels in No. IX was about average, two of the scions had small and one had large vessels.

From this information it appears that scions with large vessels do not necessarily induce an increase in size of vessel in the rootstock, as compared with the unworked rootstock, or with a No. IX grafted with a scion which has small vessels.

Table I.

Diameters of Vessels from transverse sections of Roots of No. IX Rootstocks Grafted with various Apple varieties, and of Scion Roots where present.

Scion variety.	No. IX. root.			Scion root.		
	Average size in μ.		Mean area of a vessel in sq. μ.	Average size in μ.		Mean area of a vessel in sq. μ.
	Longest diameter.	Shortest diameter.		Longest diameter.	Shortest diameter.	
Ribston Pippin	42·92	36·72	1237·81	80·12	61·86	3892·62
Feltham Beauty	39·92	29·10	912·37	40·00	30·26	950·65
Lord Grosvenor	35·92	26·46	746·48	68·20	52·20	2796·06
Blenheim Orange	42·72	32·52	1091·12	69·40	53·52	2917·20
Wellington	34·40	25·46	687·87	69·80	50·06	2744·34
Early Victoria	41·00	30·46	980·85	63·20	43·12	2140·36
Striped Beefing	38·46	26·06	787·18	66·80	51·86	2720·82
Rival	41·52	30·66	999·81	41·26	29·00	939·76
Gascoigne's Scarlet	30·86	20·26	491·05	44·72	37·52	1317·81
Gladstone	35·00	25·72	707·02	50·32	35·60	1406·96
Lady Sudeley	37·72	27·40	811·73	38·40	28·72	866·18
Bramley's Seedling	35·52	25·26	704·69	94·12	63·92	4725·08
King of the Pippins	35·86	28·32	797·62	64·72	48·40	2460·99
Peasgood's Nonsuch	35·00	20·60	566·27	71·26	51·80	2899·12
Average for 14 trees	**37·63**	**27·50**	**812·76**	**61·59**	**45·56**	**2203·86**
Charles Ross	39·52	28·06	870·95	—	—	—
Devonshire Quarrenden	45·86	32·92	1185·73	—	—	—
Norfolk Beauty	46·72	29·12	1068·53	—	—	—
Laxton's Superb	34·86	23·94	655·46	—	—	—
Stirling Castle	45·92	29·40	1058·94	—	—	—
Gravenstein	40·00	28·72	902·27	—	—	—
Beauty of Bath	40·06	28·72	903·62	—	—	—
Grenadier	36·06	21·40	606·08	—	—	—
Claygate Pearmain	46·20	34·06	1235·88	—	—	—
Baumann's Reinette	41·80	27·06	888·37	—	—	—
King's Acre Pippin	35·60	21·26	594·44	—	—	—
Lane's Prince Albert (1932)	41·06	24·46	788·80	—	—	—
Lane's Prince Albert (1933)	39·60	21·52	669·31	—	—	—
No. IX Rootstock (unworked)	34·26	22·26	598·97	—	—	—
Average for 28 trees	**39·08**	**27·07**	**830·87**	—	—	—

The most striking difference between the No. IX roots and the scion roots was in the relative size of the areas occupied by the various elements of which they were composed. In order to investigate this point the sections were examined by means of a Leitz projection apparatus used in connection with a Watson's Service microscope. A prism was placed on the eyepiece of the microscope to direct the image on to a horizontal table. The magnification used was 550 diameters and was obtained by using a $\frac{1}{6}$ inch objective and a No. 3 (x 8) eyepiece, with the draw tube at 18·45 cm., the distance from the face of the prism to the table being 33·9 cm.; three "fields" between 345 and 690μ from the cambium, and spaced as evenly as possible around the root, were examined on each slide. Direct negatives of the projected image were printed on bromide paper.

As a strictly accurate measurement of the area occupied by vessels, xylem fibres, medullary rays and xylem parenchyma cells by means of a planimeter, was found to take a very long time, the approximate relative areas were estimated more quickly according to the method described below.

Each photo-micrograph was cut up into pieces which were placed in four groups, viz.: (1) medullary rays, (2) xylem parenchyma, (3) xylem fibres, (4) vessels and tracheids.

Each group was numbered and kept separate. To insure a uniform moisture content of the paper, and one in equilibrium with the atmosphere of the room in which it was to be weighed, the pieces of each group were laid separately, gelatine side upwards for two days, while the temperature and moisture conditions were kept as constant as possible. A wet and dry bulb thermometer in the room showed that the moisture conditions remained approximately the same over the whole period. On the third day all the groups of cells were weighed in grams correct to the third decimal place on accurate chemical balances, without being touched by hand. From the weights so obtained the percentages of the four kinds of cells present in each microscopic " field " were calculated,

Table II.

Percentage area occupied by Xylem Fibres, Xylem Parenchyma, Vessels and Medullary Rays in certain Scion Roots, and in No. IX Rootstock.

Scion variety.	Scion root.				No. IX root.			
	Xylem fibres.	Xylem parenchyma.	Vessels.	Medullary rays.	Xylem fibres.	Xylem parenchyma.	Vessels.	Medullary rays.
Ribston Pippin ..	24·0	23·2	33·8	19·0	28·9	18·6	18·4	34·0
Feltham Beauty ..	35·2	17·1	31·7	15·9	20·8	32·4	15·2	31·6
Lord Grosvenor ..	34·5	18·7	25·5	21·4	17·5	39·2	10·6	32·7
Blenheim Orange ..	45·9	10·6	22·6	20·9	20·8	27·4	14·4	37·4
Wellington	27·5	24·9	24·4	23·3	30·8	24·5	11·4	33·4
Early Victoria ..	35·7	23·2	25·2	15·9	23·2	23·9	14·0	28·9
Striped Beefing ..	34·4	24·1	23·5	18·0	29·8	24·6	14·7	31·0
Rival	45·0	27·7	11·6	15·7	17·9	33·3	7·9	40·9
Gascoigne's Scarlet ..	33·0	31·2	17·3	18·4	28·1	28·1	6·9	37·0
Gladstone	40·6	27·2	15·6	16·6	19·8	28·3	13·8	38·1
Lady Sudeley ..	38·5	29·2	14·7	17·7	26·1	33·1	9·1	31·7
Bramley's Seedling ..	29·2	28·0	31·4	11·5	21·0	29·3	9·9	39·8
King of the Pippins	36·4	21·9	23·5	18·1	22·0	28·5	8·8	40·8
Peasgood's Nonsuch..	27·5	20·0	26·1	26·4	21·1	31·0	11·6	36·4
Average for 14 trees	**34·8**	**23·4**	**23·3**	**18·5**	**23·4**	**29·4**	**11·9**	**35·3**
Charles Ross	—	—	—	—	22·0	28·4	6·3	43·3
Devonshire Quarrenden ..	—	—	—	—	16.4	35·8	10·5	37·3
Norfolk Beauty ..	—	—	—	—	21.9	29·5	8·2	40·4
Laxton's Superb ..	—	—	—	—	30.8	13·3	12·3	43·6
Stirling Castle ..	—	—	—	—	20.9	24·3	10·5	44·4
Gravenstein	—	—	—	—	18.5	28·5	10·6	42·4
Beauty of Bath ..	—	—	—	—	23.6	22·5	12·3	41·7
Grenadier	—	—	—	—	12.6	28·9	7·3	51·3
Claygate Pearmain ..	—	—	—	—	24.4	20·6	16·4	38·6
Baumann's Reinette	—	—	—	—	27.8	19·7	15·1	38·5
King's Acre Pippin ..	—	—	—	—	21.1	31·8	6·6	40·5
Lane's Prince Albert (1932)	—	—	—	—	23·6	23·0	10·2	43·2
Lane's Prince Albert (1933)	—	—	—	—	18·4	25·5	10·5	45·6
No. IX (unworked) ..	—	—	—	—	19·4	25·8	13·2	41·6
Average for 28 trees	—	—	—	—	**22·5**	**27·5**	**11·3**	**38·8**

and the averages for the three "fields" on each slide are presented in Table II. The variation in the weight of the paper was estimated on fifty-four sheets and found to be 1·1 per cent. of the mean.

Counts were made of xylem fibres and parenchyma cells on the photo-micrographs before they were cut up. (See Table III.) The area of a definite weight of paper was measured with a planimeter, and from this information combined with the counts the approximate average size of the xylem fibres and parenchyma cells was calculated. (See Table IV.) In every variety, except three, i.e. Gascoigne's Scarlet, Lady Sudeley, and Peasgood's Nonsuch, the xylem fibres are larger in the scion than in the corresponding No. IX roots. The xylem parenchyma cells in seven varieties are larger, and in seven varieties smaller, in the No. IX than in the corresponding scion roots. It is apparent from the figures given in Table III that the No. IX roots have fewer xylem fibres than the scion roots, except in Bramley where the numbers are equal, and in Wellington and Ribston where there are more xylem fibres in the No. IX than in the scion roots. Although the No. IX and the scion root of the Bramley tree have an equal

Table III.

Average Number of Xylem Fibres and Parenchyma Cells in a Microscopic Field of 93,729 sq. μ from Slides of No. IX Rootstock Grafted with Various Apple Varieties, and of Scion Roots where present.

Scion variety.	No. IX root.		Scion root.	
	Xylem fibres.	Xylem parenchyma cells.	Xylem fibres.	Xylem parenchyma cells.
Ribston Pippin	157	72	95	55
Feltham Beauty	120	64	154	55
Lord Grosvenor	94	73	142	67
Blenheim Orange	96	46	139	28
Wellington	138	67	108	42
Early Victoria	112	80	170	71
Striped Beefing	114	64	125	55
Rival	88	56	178	75
Gascoigne's Scarlet	115	76	152	58
Gladstone	98	51	170	57
Lady Sudeley	108	65	182	74
Bramley's Seedling	103	88	103	46
King of the Pippins	109	76	154	50
Peasgood's Nonsuch	93	50	143	48
Charles Ross	97	69	—	—
Devonshire Quarrenden	85	71	—	—
Norfolk Beauty	68	58	—	—
Laxton's Superb	164	48	—	—
Stirling Castle	98	68	—	—
Gravenstein	75	52	—	—
Beauty of Bath	119	63	—	—
Grenadier	51	55	—	—
Claygate Pearmain	105	54	—	—
Baumann's Reinette	115	56	—	—
King's Acre Pippin	100	78	—	—
Lane's Prince Albert (1932)	96	67	—	—
Lane's Prince Albert (1933)	104	71	—	—
No. IX Rootstock (unworked)	101	80	—	—

Table IV.

Average Area of a Xylem Fibre and a Xylem Parenchyma Cell in Transverse Sections of No. IX Rootstock and in certain Scion Roots.

Scion variety.	Xylem fibres.		Xylem parenchyma.	
	No. IX root sq. μ.	Scion root sq. μ.	No. IX root sq. μ.	Scion root sq. μ.
Ribston Pippin	177·4	239·4	249·3	402·6
Feltham Beauty	169·1	219·9	492·6	298·4
Lord Grosvenor	182·3	237·7	523·2	273·3
Blenheim Orange	211·3	317·8	575·3	369·3
Wellington	212·0	251·2	351·1	590·2
Early Victoria	201·5	204·1	412·5	318·5
Striped Beefing	250·2	270·4	366·0	426·3
Rival	197·5	247·3	571·4	359·1
Gascoigne's Scarlet	237·4	206·7	359·1	513·4
Gladstone	196·5	231·5	546·3	461·3
Lady Sudeley	235·7	202·4	496·9	377·5
Bramley's Seedling	193·2	275·6	316·2	587·5
King of the Pippins	189·9	231·8	354·4	431·3
Peasgood's Nonsuch	219·3	186·2	601·1	400·9
Charles Ross	217·6	—	392·4	—
Devonshire Quarrenden ..	186·9	—	488·9	—
Norfolk Beauty..	312·2	—	489·3	—
Laxton's Superb	182·3	—	269·0	—
Stirling Castle	205·4	—	346·9	—
Gravenstein	241·7	—	533·1	—
Beauty of Bath	194·8	—	350·2	—
Grenadier	238·0	—	504·4	—
Claygate Pearmain	222·2	—	365·0	—
Baumann's Reinette	223·2	—	332·7	—
King's Acre Pippin	203·1	—	393·0	—
Lane's Prince Albert (1932) ..	243·0	—	335·6	—
Lane's Prince Albert (1933) ..	174·4	—	354·4	—
No. IX Rootstock (unworked)	187·4	—	313·6	—

number of xylem fibres, the fibre cells are so much larger in the scion root than in the No. IX root, that the percentage area occupied by xylem fibres is considerably greater in the scion root than in the No. IX root. The xylem fibres in Wellington and Ribston scion roots are also larger than in the No. IX roots. There are more xylem parenchyma cells in the No. IX roots than in the scion roots, with the exception of Gladstone, Rival and Lady Sudeley, where there are slightly less. In these three trees there is, however, a greater percentage area occupied by xylem parenchyma in the No. IX than in the scion roots owing to the greater size of the parenchyma cells in the No. IX roots.

Although the structure of the roots within the group of No. IX appears to show considerable variation, in certain respects it remains remarkably constant ; for example, all these roots are characterized by a very large percentage of medullary ray tissue and a small percentage of vessels. In the twenty-eight trees taken the medullary rays occupied on an average 38 per cent., the vessels 11·3 per cent., the xylem fibres 22·5 per cent. and the xylem parenchyma 27·5 per cent. of the total area examined. On the whole the scion varieties have much less medullary ray tissue, and a far greater amount of vessels and xylem fibres than the No. IX roots. (See Figs. 1 and 2, 3 and 4.)

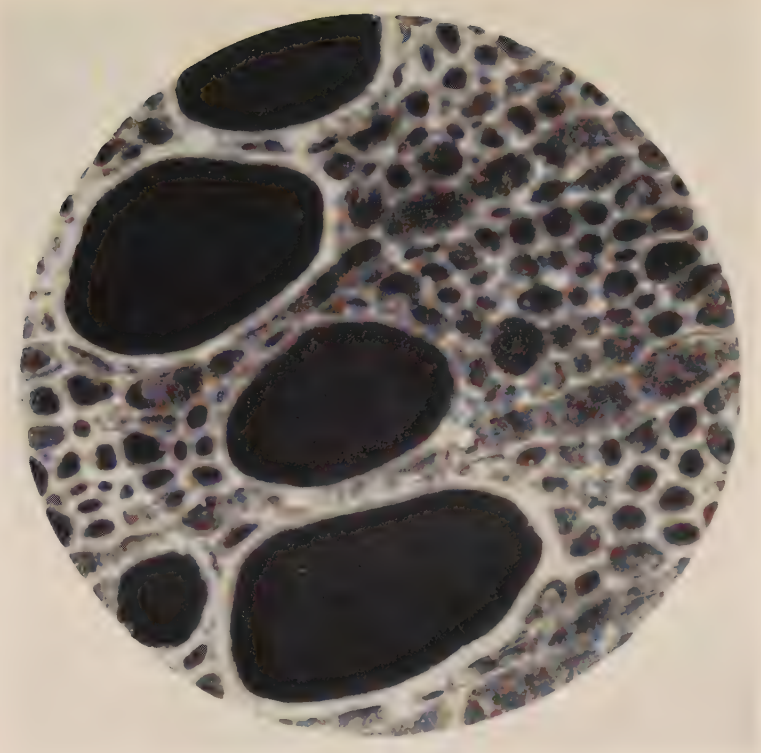

FIG. 1.
T.S. Scion Root of Bramley's Seedling (×275).

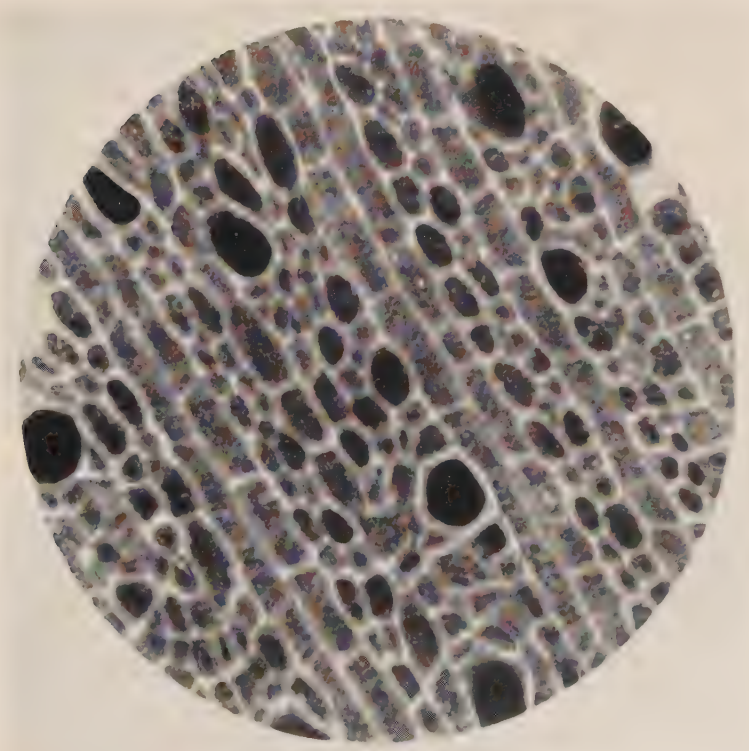

FIG. 2.
T.S. Root of No. IX Grafted with Bramley's Seedling (×275).

Photo-micrographs of transverse sections of the wood of a root of No. IX grafted with Bramley's Seedling and of a scion root from the same tree. (Reduced to half size from projection prints prepared as described in the text.)

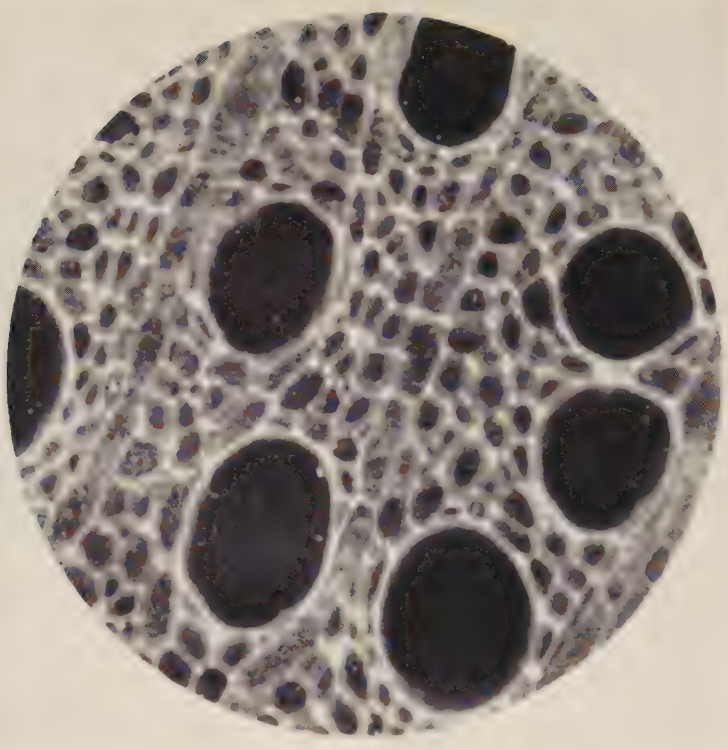

FIG. 3.
T.S. Scion Root of Blenheim Orange (×275).

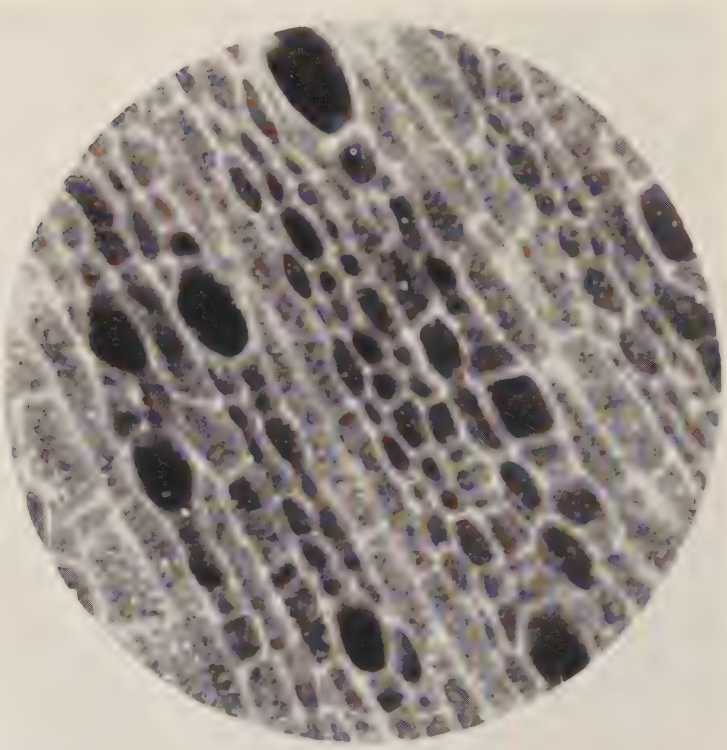

FIG. 4.
T.S. Root of No. IX Grafted with Blenheim Orange (×275).

Photo-micrographs of transverse sections of the wood of a root of No. IX grafted with Blenheim Orange and of a scion root from the same tree. (Reduced to half size from projection prints prepared as described in the text.)

As shown above with reference to size of vessels, a rootstock grafted with a scion variety having a root structure very different from its own, appears to keep its own structure rather than to undergo a change which would make it more like its scion. For example, No. IX grafted with Bramley's Seedling, which has a very low percentage of medullary ray and an exceptionally large area of vessels, has only 10 per cent. of vessels, which is below the average, and 40 per cent. of medullary ray, which is above the average for No. IX. Similar conditions are also observed in eight other varieties. Two varieties, Rival and Gladstone, have about the same percentage area of vessels as No. IX. They have, however, a low percentage of medullary ray, tissue and an exceptionally high percentage of xylem fibres, but they do not appear to have induced an increase in the amount of xylem fibres or a decrease in the amount of medullary ray tissue in the roots of the No. IX on which they have been grafted. Peasgood has a greater amount of medullary ray tissue than any of the other scion roots examined, but differs from No. IX in having a far higher percentage area of vessels.

When the relative area occupied by living to lignified cells is calculated by dividing the weight (obtained from the photo-micrographs) of xylem parenchyma and medullary rays by the weight of xylem fibres and vessels, it is apparent that in every case the No. IX roots give a number greater than unity, showing that they possess a larger amount of living than lignified cells, whereas all the scion roots give a number less than unity, which indicates that they have more lignified than living tissue. (See Table V.)

TABLE V.

AREA OCCUPIED BY LIVING CELLS COMPARED WITH THAT OF LIGNIFIED CELLS (THE LATTER REPRESENTED BY UNITY) IN THE WOOD OF No. IX AND SCION ROOTS.

Scion variety.	No. IX root.	Scion root.
Ribston Pippin	1·113	0·731
Feltham Beauty	1·783	0·493
Lord Grosvenor	2·560	0·667
Blenheim Orange	1·836	0·459
Wellington	1·372	0·927
Early Victoria	1·690	0·640
Striped Beefing	1·252	0·727
Rival	2·870	0·766
Gascoigne's Scarlet	1·862	0·987
Gladstone	1·980	0·779
Lady Sudeley	1·838	0·881
Bramley's Seedling	2·237	0·651
King of the Pippins	2·255	0·668
Peasgood's Nonsuch	2·062	0·867
Charles Ross	2·535	—
Devonshire Quarrenden	2·721	—
Norfolk Beauty	2·321	—
Laxton's Superb	1·320	—
Stirling Castle	2·185	—
Gravenstein	2·434	—
Beauty of Bath	1·791	—
Grenadier	4·041	—
Claygate Pearmain	1·449	—
Baumann's Reinette	1·388	—
King's Acre Pippin	2·612	—
Lane's Prince Albert (1932)	1·958	—
Lane's Prince Albert (1933)	2·457	—
No. IX Rootstock (unworked)	2·064	

To show that the characteristics of No. IX rootstock persist on various soils, under different weather conditions, and with trees of different ages, trees other than those from Wye were examined. Slides selected for examination were prepared from :

(*a*) A root (sectioned in 1936) from an unworked twenty-two year-old tree of No. IX.

(*b*) Roots of two-year-old trees of No. IX grafted with Lane's Prince Albert, which had been lifted and recorded in 1932.

(*c*) Roots of three-year-old trees of No. IX grafted with Lane's Prince Albert lifted in 1933.

All these trees were grown on East Malling soil. In all the specimens taken of this rootstock, worked and unworked alike, calculations showed that the proportions of the different cells were similar to those obtained from the set of trees from Wye.

Nightingale has proved that a change in root structure can be induced by varying the temperature and moisture conditions under which the trees are grown (1). From our findings it appears, however, that in England the conditions for tree growth do not vary sufficiently to alter the structure of No. IX rootstock beyond the point of easy recognition.

Summary.

An examination was made of the anatomical structure of the wood of roots of No. IX rootstocks, some unworked, others grafted with twenty-six apple varieties, and this structure was compared with that of the scion roots which were present in fourteen varieties. Measurements of the vessels, in terms of the diameters as seen in transverse section, were made. The percentage of the medullary ray tissue, xylem parenchyma, xylem fibres and vessels of which the wood of these roots was composed, was estimated by means of weighings of the corresponding parts cut from photographic prints of the transverse sections.

Acknowledgments.

The authors wish to express their gratitude to Mr. R. T. Pearl for the material and the projection apparatus used. It was entirely owing to his kindness and interest that the work was made possible. They also wish to record their thanks to Mr. H. B. S. Montgomery for valuable advice and criticism.

Reference.

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THE ROOT SYSTEMS OF SOME THREE-YEAR-OLD TREES OF LANE'S PRINCE ALBERT ON TWO SELECTED ROOTSTOCKS (MALLING No. II × NORTHERN SPY)

By H. M. TYDEMAN

Work has been in progress for a number of years at the East Malling Research Station on the raising and testing of new varieties of apple rootstock immune from attack by Woolly Aphis. The work has, so far, largely consisted in the crossing together of immune varieties such as Northern Spy and the Malling series of Paradise apple rootstocks. The seedlings have been raised partly at the John Innes Horticultural Institution and partly at East Malling. The immunity of the seedlings is determined by artificial inoculation methods (1, 2) and those seedlings which have proved immune are subsequently tested both as to the ease with which they can be propagated by vegetative means and as to their influence upon the scion variety (3, 4).

Four seedlings from a family Malling No. II (Doucin) × Northern Spy, raised at Merton in 1924, and of proved immunity from Woolly Aphis, under our conditions, have been under trial here for a number of years. Each seedling has been propagated in quantity and worked with the scion variety Lane's Prince Albert.

Until comparatively recently, it was not found possible to lay down complete trials of these seedlings owing to the difficulty of obtaining sufficient layers. However, as material became available small preliminary trials were planted in the hope that they would afford some indication of the value of these seedlings as rootstocks, pending the production of material for more exhaustive trials. The trees in one of these preliminary trials were dug up during the autumn of 1935 in order that the root systems could be examined. These trees were Lane's Prince Albert budded in 1932 on clonal rootstocks derived from two seedlings Nos. 789 and 779 of the above mentioned family together with others on Malling Nos. IX, II and XII, as controls, comprising altogether 138 trees in randomized blocks of six trees each. Since it was desired to examine their root systems, the trees were excavated with considerable care, a trench being dug out on either side and the roots traced as far as practicable to their ultimate tips. Measurements and weights of the various parts of the trees were obtained and are summarized in Tables I and II.

Table I.

Average Wood Growth and Tree Weights. Three-year-old Budded Trees.

Root-stock.	Number of Trees.	Length of One Year Wood.	Number of Laterals.	Diameter of Stem.	Weight of Tree.	Weight of One Year Wood.	Weight of Older Wood.	Weight of Roots.
		cm.		cm.	grams.	grams.	grams.	grams.
789	23	1086·5	32·4	3·07	2411	198	1327	886
779	47	1064·3	34·0	2·97	2254	180	1152	922
IX.	24	531·0	24·8	2·02	1039	76	531	432
II.	23	902·9	32·2	2·79	1840	162	990	688
XII.	21	1492·7	45·2	3·10	2663	220	1399	1044

With regard to the average length of the one year wood, shown in Table I, it may be seen that the trees on both the seedlings of No. II × Spy made slightly more wood than those on Malling No. II. They do not, however, differ perceptibly from one

TABLE II.

ANALYSIS OF ROOT SYSTEMS. THREE-YEAR-OLD BUDDED TREES.

	Average Depth of Roots.	Average Spread of Roots.	Average Number of Main Roots.	Total Average Weight of Root System.	Average Weight of Stock Stem.	Average Weight of Coarse Roots.	Average Weight of Fibre.	Weight of Fibre as Percentage of Total Weight of Roots.
	cm.	cm.		grams.	grams.	grams.	grams.	
789	35·4	69·0	3·8	604·6	331·7	266·1	6·8	2·5
779	36·2	81·6	3·3	526·5	311·4	196·2	18·9	8·8
IX.	29·9	59·9	2·5	—	—	—	—	—
II.	36·0	72·7	3·7	445·9	249·7	189·1	7·1	3·6
XII.	41·2	88·8	5·9	—	—	—	—	—

another. In the case of the trees on No. 789, the average weight of the older wood on each tree, i.e. all that remains of the tree after the current year's wood and the roots

TABLE III.

ANALYSIS OF ROOT SYSTEMS. ONE-YEAR BUDDED LAYERED ROOTSTOCKS.

	Number of Stocks.	Weight of Entire Stock.	Weight of Wood.	Weight of Coarse Root.	Weight of Fibre.	Weight of Fibre as Percentage of Total Weight of Roots.
		grams	grams.	grams.	grams.	
789	10	57·6	45·7	6·6	5·3	44·5
779	12	41·0	23·1	1·0	16·9	94·4
II.	10	73·4	62·5	5·4	5·5	50·5

have been removed, is considerably greater than in the case of trees on No. 779; it is almost as heavy as that of the trees on No. XII. Trees on both the No. II × Spy selections were considerably heavier than those on No. II.

It is extremely difficult to draw any definite conclusions as to the relative vigour of these two selections when used as rootstocks for Lane's Prince Albert. From the data given in Table I, the inference might be drawn that they resemble one another fairly closely in their influence on the scion variety and fall into an intermediate class for vigour. This is borne out by the records of wood growth of the previous year. On the other hand results from two trials of older trees, while not conclusive, since comparable trees upon

the two selections are not available, would suggest that No. 779 makes a much less vigorous tree with Lane's Prince Albert than does No. 789. Since, however, trees in all these trials are still comparatively young, undue emphasis should not be placed upon any estimates of their relative vigour.

There was a period of several days between the time when the excavations were made and that at which the root analyses were obtained. This accounts for the difference in the weights of the root systems given in Table I, and those given in Table II. In general it may be said that the root systems of the trees on No. 789 were entirely different from those on No. 779. In the former case the main framework of the root system consisted of stout fangy roots spreading out almost horizontally while fibre was almost entirely absent. The root systems resembled very closely those of trees on No. II. In the case of trees on No. 779, the main roots were much less coarse although inclined to be horizontal and spreading. Fibre was abundant more particularly around the collar and at the base of the main roots. As may be seen from Table II, while only 2·5 per cent. of the total root system of trees on No. 789 consisted of fibre, in the case of trees on No. 779 it was as much as 8·8 per cent. No comparable trees on Northern Spy were available for excavation. Observations at various times upon older trees, however, have shown that Northern Spy is characterized by a horizontal, spreading root system in which fibre is plentiful.

For purposes of comparison an analysis of the root systems of unworked layered stocks of these two selections are given in Table III. It may be seen that whereas about 50 per cent. of the root system of stocks of No. 789 consist of fibre, those of No. 779 are more than 94 per cent. fibre.

It is of considerable interest that in a single family of seedlings so wide a range of variation in the character of the root systems should have been found. Until the root systems of further members of this family have been excavated and examined it will not be possible to ascertain whether the variation is discontinuous or whether the two examples described in this paper are simply extremes in a continuous range, but it is obvious that genetical segregation has been responsible for the production of these two extremely different types of root system. In a previous study (5) the writer found wide differences in the relative proportions of fibre borne on the root systems of young unworked seedlings from a large number of crosses between Paradise apple rootstocks. The data now presented indicate that such differences are not lost in the processes of vegetative propagation and the subsequent overworking of the rootstocks with a scion variety.

Summary.

Comparative measurements and weights of both the wood and the roots of 138 three-year-old trees of Lane's Prince Albert worked on two selections, Nos. 779 and 789, from Malling No. II × Northern Spy, are summarized and discussed. The trees of both selections are shown to have made a slightly greater amount of wood growth and to be slightly heavier than trees on No. II but to be decidedly less vigorous than those on No. XII.

An analysis of the root systems of trees on these two selections is presented. The root systems of trees on the two selections are shown to be widely different. Those of trees on No. 789 are very similar to those of trees on No. II. Whereas with trees on No. 789 only 2·5 per cent. of the total weight of the roots, on the average, consisted of fibre, in the case of trees on No. 779 the percentage was 8·8 per cent. The wide differences in the root systems of trees on the two selections are considered to be of genetic origin.

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(2) Massee, A. M. "The Resistance of Certain Apple Stocks to Attacks of the Woolly Aphis." E. Malling Res. Sta. Ann. Rep. for 1928-30 (II Supplement), 1931, 202-5.

(3) Tydeman, H. M. "The Testing of New Varieties of Apple Rootstock." A Progress Report. E. Malling Res. Sta. Ann. Rep. for 1933, 94-9.

(4) ——— "Apple Rootstocks Immune from Woolly Aphis. A Progress Report on Trials with New Varieties." E. Malling Res. Sta. Ann. Rep. for 1934, 115-22.

(5) ——— "Breeding Experiments with 'Paradise' Apple Rootstocks." Journ. Pom. and Hort. Sci., 1933, **11,** 214-36.

FIG. 1.
Root System of Seedling 789 (No. II × Spy).
(Note little fibre.)

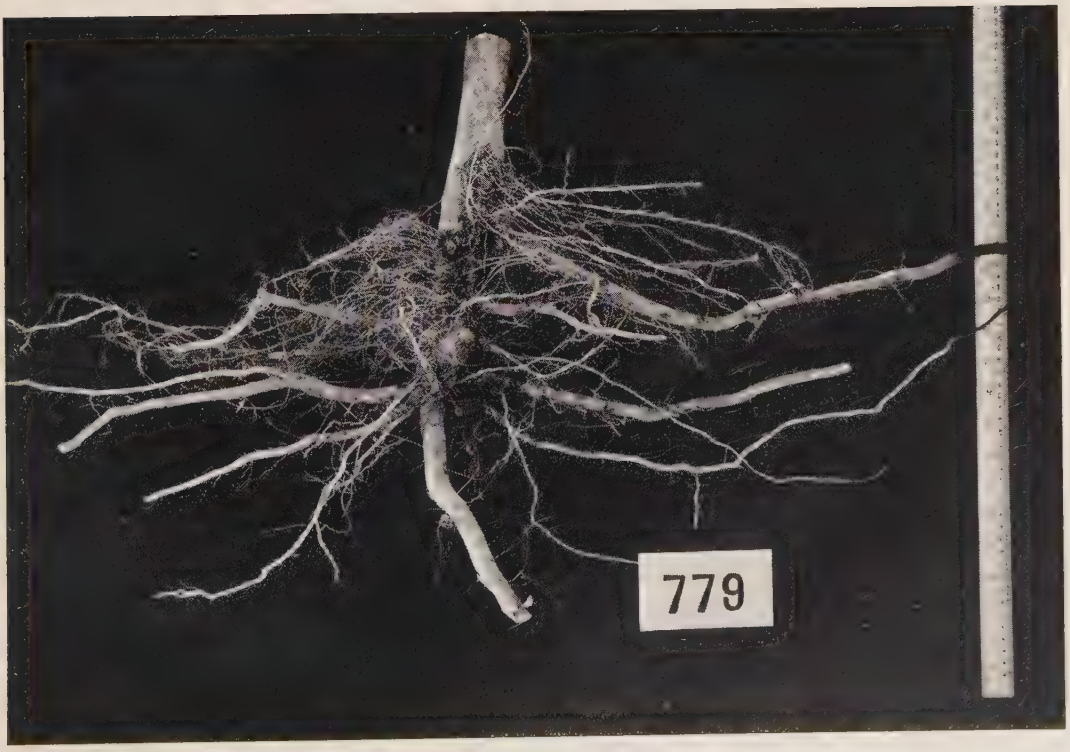

FIG. 2.
Root System of Seedling 779 (No. II × Spy).
(Note much fibre.)

THE RELATION OF SOIL MOISTURE TO PLANT GROWTH, ILLUSTRATED BY MOISTURE METER EXPERIMENTS WITH STRAWBERRIES

By W. S. ROGERS

It is well known that soil moisture is one of the most important factors in plant growth. Plants make their best growth within certain limits of moisture. If the upper limit is passed, water-logged conditions result, and the plant growth is unhealthy. If the lower limit is passed, absorption is checked and eventually wilting occurs. The optimum moisture conditions and the limits at which harm results may vary with the species of plant. For instance the conditions that suit a rush best are not ideal for a cactus. Precise knowledge of these optimum and limiting conditions is clearly desirable for all commercial plants. The comparatively scanty knowledge of the factors mentioned above, and also of seasonal soil moisture variations and the water movements in the soil is probably largely due to the lack of convenient moisture measuring instruments. The standard technique of taking a soil sample and drying it is too laborious and slow for extended use.

The instrument described in this paper gives a continuous measurement of the soil moisture conditions by indicating the " capillary pull " or " suction force " of the soil. This force is due mainly to the surface tension of the water film surrounding the soil particles, and it varies with the amount of moisture in the soil, the size of the soil particles and the degree of compactness of the soil. Since the last two factors remain constant in a given position, variations in the suction correspond with variations in the moisture content. To read actual moisture percentage the instrument has to be calibrated for the soil in which it is placed. Once this is done, all sampling and weighing is eliminated.

The suction force itself is possibly a more valuable figure than the moisture percentage, since it probably relates more nearly to the resistance of the soil to water intake by the plant than any other single measurement at present available.

Construction of the Moisture Meter.

This instrument measures the suction force by means of a thick walled fine grained porous pot filled with water, buried in the soil at the required depth, and connected by a copper tube to a mercury manometer or a vacuum gauge (Fig. 1). In field models of the manometer type the glass capillary tube is held in a sloping wooden framework, which makes reading easier and magnifies the mercury movements. Photographs of this type appear in other papers (2, 4). The soil draws water out of the porous pot until the manometer height corresponds to the pull of the soil. When the soil becomes drier or wetter water passes out of, or back into, the pot with a corresponding rise or fall of the mercury.

The range of the instrument covers suction forces from 0 to about 65 cm. of mercury. This corresponds to moisture contents from saturation to about 1·5 per cent. moisture (calculated on dry weight) in sand, 8 per cent. in light loam, and 21 per

cent. in heavy clay. In terms of the pF scale introduced by Schofield (5) the range of the instrument is from pF 0·5 to about pF 2·9. The pF is the logarithm of the suction force in centimetres of water. In a graph drawn to this scale the suction changes at the lower values are therefore considerably accentuated, which is more convenient for certain purposes. There is no difficulty in using either the ordinary suction or the pF scale as required.

When the suction force exceeds about 66 cm. Hg (pF 2·95) there is no further rise in the reading of the instrument, and the water is gradually withdrawn from the porous pot. Under such conditions (which may exist in a severe drought) the instrument can be refilled as often as is required by means of the filling tubes which are provided.

It must be emphasized, however, that beyond the point when about pF 2·95 has been reached, we can only say that the suction is pF 2·95 or more.

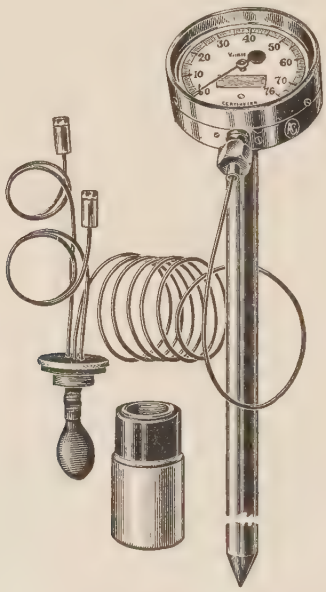

FIG. 1.

Soil Moisture Meter, showing porous pot, vacuum gauge, filling tubes and anti-freezing device.

A special device is used to prevent freezing and errors due to air dissolved in the soil water. This consists of a flexible rubber sac fixed at the base of the main tube, inside the porous pot. The main tube and sac contain an air-free 50 per cent. glycerine solution. Two filling tubes with detachable stoppers are fitted, for filling and removing air from the porous pot when in position (Fig. 1). Very careful workmanship is required, since every join must be perfectly airtight.

Full particulars of the construction of the instrument are given in a former article (2).

LAG IN READINGS.

A point not previously discussed is the lag in reading due to the thickness and density of the porous pot. It is necessary to use a specially dense pot because ordinary

porous pots allow air to enter at quite low suction forces ; but this density limits the rate of flow of water through the walls. The amount of water passing out of or back into the manometer or the vacuum gauge of the instrument over the range from zero to pF 2·9 is about 5 cc.

The percolation rate of the present series of pots ranges from nil at no head to about 12 cc. per hour at a head of 65 cm. Hg, following approximately a straight line relationship. It is therefore to be expected that the change from 0 to 65 cm. (at a mean flow of 6 cc. per hour) will take about an hour. This is assuming the water in the pot to be air-free. In practice it is usually not so, even if it is boiled at first, since it acquires air from the soil solution. If 2 cc. of air were in the pot, this would expand to 15·2 cc. at a pull of 65 cm. Hg and would delay the reaching of equilibrium by a further $2\frac{1}{2}$ hours.

In the field the soil at 1 ft. takes weeks or even months to dry from saturation to pF 2·9 (60 cm. Hg) hence a lag even of 2 or 3 hours is quite immaterial. Nearer the surface or in pot experiments where drying is more rapid, the lag may have to be taken into account.

Similarly in wetting (which is usually rapid within a limited area) the lag needs to be taken into account. But it should be noted that on the change from drying to wetting conditions the gauge shows the *beginning* of a fall within a few minutes, though it may take several hours to reach the final value.

This lag can be minimized by refilling fairly frequently with boiled water. A further possibility is the use of larger pots and smaller gauges, but in this connection convenience of handling and errors in small gauges form a limiting factor.

Relation of Suction to Moisture Content.

An important point concerning the relation of moisture content to the pressure deficiency of the soil demonstrated by Schofield (5) is that the moisture : suction-force curve shows hysteresis, i.e. does not follow exactly the same course for drying conditions as for wetting conditions. The hysteresis prevents absolutely precise translation of the suction force into terms of moisture content. Actual field and laboratory tests of moisture percentage at given readings of the meter show that under these conditions the variation is not so large as might be expected, however. Examples of the relation between soil moisture and the suction force shown by the meter are given in Fig. 2, which is reproduced from a former paper (2). This diagram shows the readings of meters placed in cans of soil whose moisture content was determined at intervals by weighing. A number of curves obtained by drying and re-wetting the soil are given, and it can be seen that the spread of the curve is generally within a 10 per cent. variation of the moisture percentage. The great influence of particle size on the suction force at a given moisture content is also evident.

The relation of the meter readings in the field to the " wetting " and " drying " curves as obtained in the laboratory by Schofield (5) is at present a little obscure. There are indications that the curve given by the moisture meter for drying conditions in the field falls somewhat below the " drying curve " obtained by Schofield's technique. A series of experiments is in preparation to elucidate these points.

Seasonal Moisture Changes.

An example of the way in which these meters show the seasonal changes of soil moisture is given in Fig. 3, which shows a year's readings of instruments installed at

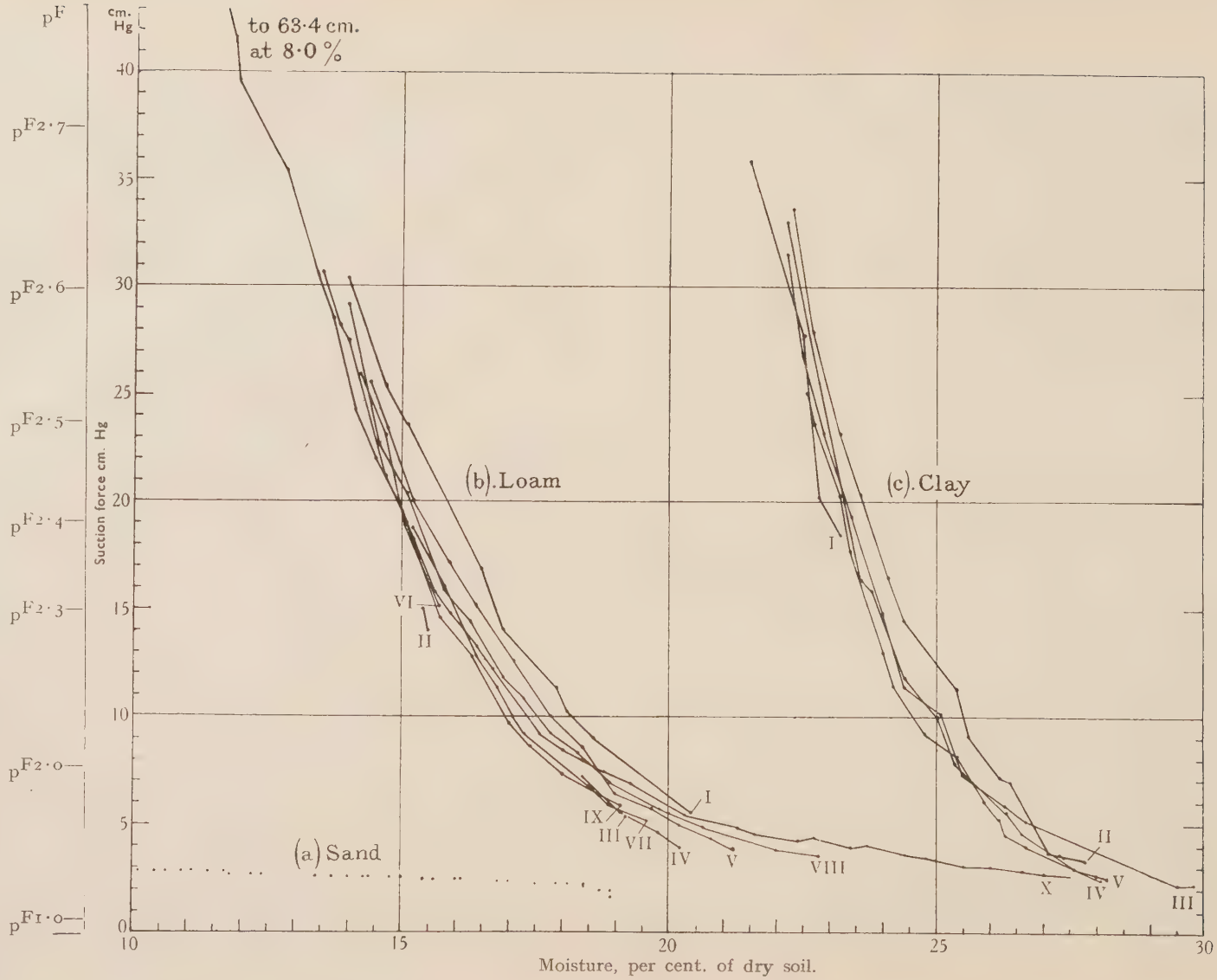

FIG. 2.

Moisture : suction-force curves for sand, loam and clay.

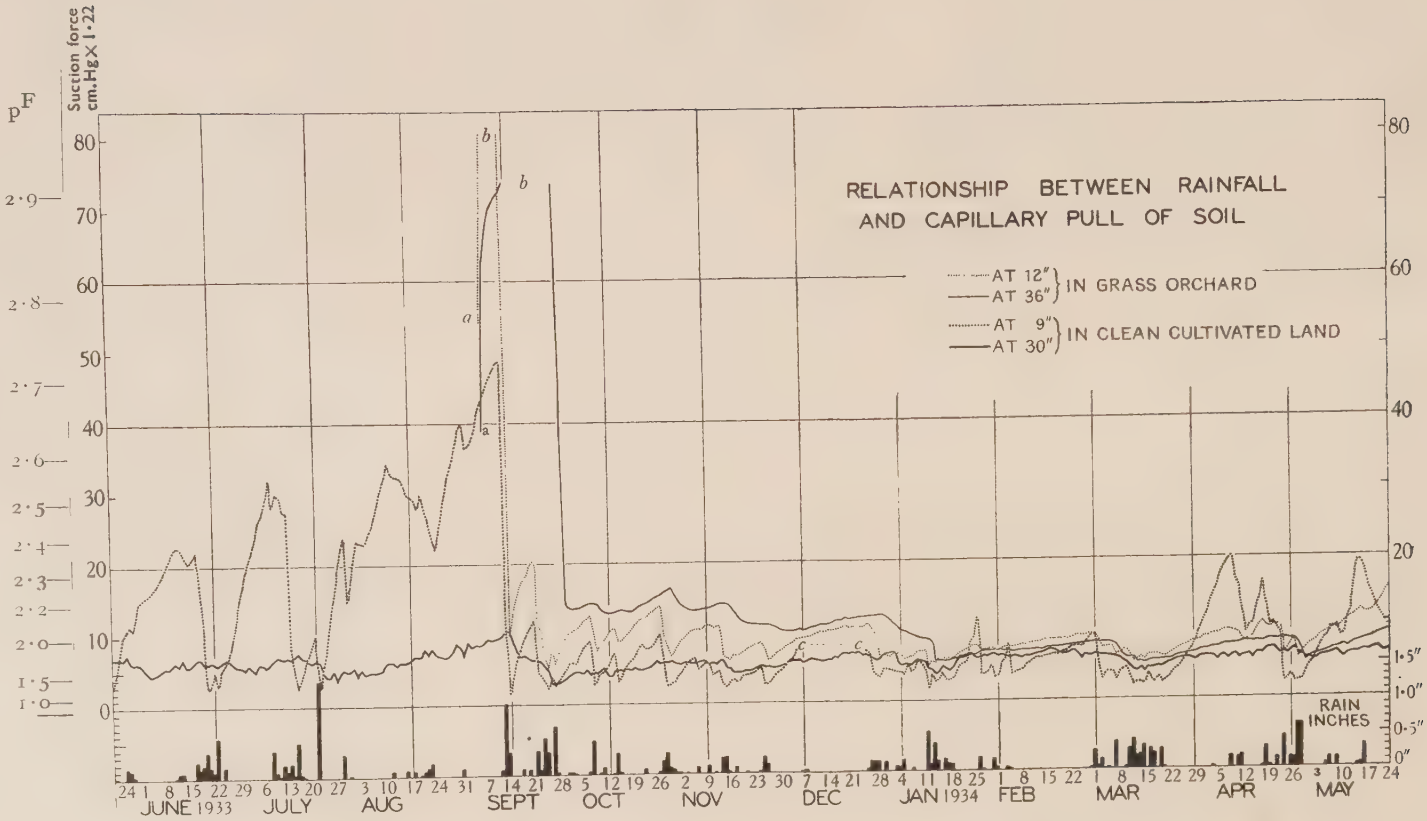

FIG. 3.

Rainfall and suction force at two depths in fallow land and grass orchard at East Malling.

9 inches and 30 inches in clean cultivated land and at 12 and 36 inches in a grass orchard.*

It can be seen that in clean cultivated land both drying and wetting take place more rapidly near the surface than deeper down. The clean cultivated soil reached a pF of over 2·7 at 9 inches after five weeks drought in August, but the same soil at 30 inches hardly dried at all, showing how slow is the upward movement of water by capillary action. The meters installed in the grass orchard in September quickly rose to more than pF 2·9 both at 1 ft. and at 3 ft., showing that the soil was dried out by plant roots to more than 3 ft. A rainfall of about 1·4 inches re-wetted the soil at 1 ft. early in September, but the soil at 3 ft. remained at above pF 2·9 for a further sixteen days by which time a total of 3·56 inches of rain had fallen since the breaking of the drought.

The results are discussed more fully in a former paper (2) from which this diagram is taken. The points of particular importance with reference to the data which follow are that in December, January and February the soil is usually below pF 2·0. In March, it usually begins drying, and from May onwards the rainfall, so far as the dry summers of 1933, '34 and '35 are concerned, is quite insufficient to make up for water usage in a grass orchard, and the pF rises steadily both at 1 ft. and at 3 ft.

TABLE I.

INCIDENCE OF DROUGHT IN GRASS ORCHARD AT MALLING.

	Date of drying to					Date of re-saturation to
	pF 2·5 (23 cm. Hg).	pF 2·6 (29 cm. Hg).	pF 2·7 (37 cm. Hg).	pF 2·8 (47 cm. Hg).	pF 2·9 (59 cm. Hg).	pF 2·0 (7 cm. Hg).
1934.						
Soil at 1 ft.	June 2nd.	June 5th.	June 9th.	June 11th.	June 15th.	October 3rd.
Soil at 3 ft.	June 17th.	June 19th.	June 22nd.	June 24th.	July 14th.	December 10th.
1935.						
Soil at 1 ft.	June 29th.	July 2nd.	July 4th.	July 6th.	July 9th.	September 1st.*
Soil at 3 ft.	July 10th.	July 15th.	July 17th.	July 26th.	August 9th.	October 9th.*

* Date estimated from meters in adjacent cultivated orchard. Grass orchard meter broken.

The incidence of the drought in 1934 and 1935 is shown in Table I. It will be noted that pF 2·8 was reached at 1 ft. on 11th June in 1934, and on 6th July in 1935. Re-saturation to pF 2·0 at 1 ft. depth occurred on 3rd October in 1934, and 1st September in 1935. This is some measure of the fiercer intensity of the drought in 1934. The amount of rain which fell between the date of reaching pF 2·9 and the date of re-saturation to pF 2·0 at 1 ft. in 1934 (i.e 15th June to 3rd October) was 7·20 inches, and the additional rainfall before the 3 ft. meter reached pF 2·0 again (10th December) was 5·43 inches—a total of 12·63. In 1935 the rainfall between the time of reaching pF 2·9 and re-saturation to pF 2·0 at 1 ft. (i.e. 9th July to 1st September) was 3·69 inches. This gives another comparison of the greater severity of drought in 1934 than in 1935. Of course these rainfall figures do not represent merely the amount of water required to re-moisten the soil, but the amount required to do this in addition to making up current evaporation and plant transpiration losses.

* The factor 1·22 by which the suction scale must be divided to obtain vacuum in cm. Hg is due to the sloping manometer used in the field instrument, for easier reading.

Table II, which gives the monthly rainfall at East Malling from 1933-35, shows the conditions under which the above results were obtained.

TABLE II.

RAINFALL AT EAST MALLING RESEARCH STATION, 1933-35.

Monthly totals in inches.

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1933	1·52	1·46	2·33	0·85	2·21	2·01	3·18	0·69	3·56	1·73	1·14	0·66	21·34
1934	2·17	0·32	2·86	2·87	0·71	1·48	2·02	1·83	1·38	1·61	2·41	5·07	24·73
1935	1·19	3·56	0·15	3·31	1·82	1·63	0·94	2·67	3·57	3·26	5·15	3·11	30·36

Results already published (3, 4) obtained with some moisture meters installed beside a "root observation trench" in an irrigated apple orchard showed that when plenty of moisture was present the root growth varied as the soil temperature; but when the soil suction exceeded a certain value the root growth decreased rapidly, no matter how warm the soil was. This change of root growth rate was visible long before the leaves showed signs of wilting. It was suggested that the suction value for optimum growth conditions would vary with different soils, and possibly with different plants, and that for apples under sandy soil conditions a soil suction below 30 cm. Hg (approximately pF 2·6) was desirable; for the lightest soils an even lower value seems indicated.

It is clear that the rate of water intake by the root is not the only factor to be considered. The water loss from the leaves may be the controlling factor. Thus at a given rate of water intake by the root, the plant may be wilting or turgid according to whether the transpiration exceeds water intake or not. In the experiment quoted above, in hot sunshine and a dry climate, the evaporation was rapid, and although no actual wilting was observed, the leaves were probably getting short of water at the end of each day during the periods when checked root growth was observed.

Some further information is brought to light by the following experiments and observations.

POT EXPERIMENTS WITH STRAWBERRIES.

1. Moisture meters of the vacuum gauge type* were installed in two 8 inch diameter flower pots each containing one Royal Sovereign strawberry plant which had previously been growing in a deep $4\frac{1}{2}$ inch diameter flower pot for a year. The soil was kept moist until the plants were well re-established and it was then allowed to dry out naturally in a well-lighted room indoors. The results are shown in Figs. 4-9. After watering, the saturated soil gave a suction force of 0 cm. (Fig. 4). Drying of the soil by transpiration and evaporation caused the suction force to rise to 60 cm. Hg (pF 2·91) in four days. At this pressure the plant was severely wilted (Fig. 5). Sufficient water to saturate the soil was then applied, and within an hour the middle leaves of the plant were erect again. The moisture meter hand was falling and finally reached a centimetre or two above zero. By the next morning all leaves were turgid again, and the soil showed a pull of 7·2 cm. (pF 1·99). After a further 30 hours the soil pull had risen to 29 cm. (pF 2·59), at which pressure the leaves were still quite turgid as in Fig. 6.

* These meters were manufactured by Messrs. A. Gallenkamp, Ltd., Sun Street, London.

Eighteen hours later, at a pull of 45·2 cm. (pF 2·78), the beginning of wilting can be noticed in Fig. 7, and after a further seven hours quite pronounced wilting at a pull of 49·0 cm. (pF 2·82) was shown, Fig. 8. The next morning, seventeen hours later, still more severe wilting is seen, at a pull of 56·2 cm. (pF 2·87) (Fig. 9). This cycle is typical for both plants, which behaved quite consistently in this manner for four weeks, after which the experiment was discontinued. During this period the relative humidity in the screen (out-of-doors at 9 a.m.) varied from 62 to 78 per cent.

2. A similar experiment was carried out with another Royal Sovereign strawberry plant from 21st November to 11th December. In this case pronounced wilting was visible at suction values between pF 2·8 and pF 2·9. The relative humidity in the screen was about 86 per cent. in this period.

Once the plants had experienced a period of severe wilting, they appeared to wilt more readily when the same pF was approached again. This suggests that the root hairs were appreciably damaged by the wilting of the plant even for a comparatively short period. This agrees with the findings of Maximov (1).

The fact that the plants were indoors caused the new stalks to be rather more etiolated than those of outdoor plants. This probably made them show wilting more readily. The etiolation was quite slight, however, as Figs. 4-9 show.

These experiments—though only of a preliminary nature—prove that the plant under these conditions is sensitive to soil suction forces below pF 3·0 (one atmosphere). This is of considerable interest, since the " permanent wilting " point of Briggs and Shantz has been shown by Schofield (5) to approximate to pF 4·2. The strawberry plants were not tested in a saturated atmosphere, so their relation to the " permanent wilting " condition cannot be given, but the wilting was undoubtedly very severe.

3. An interesting contrast is provided by two sets of nine strawberry plants contained in " controlled moisture " frames fitted with moisture meters. The strawberries had a soil area of approximately 4 ft. by 4 ft. by 1 ft. 9 in. deep. These frames form part of a series receiving various predetermined water applications—a combined Pomological and Pathological Project—which will be reported on later. The two frames were planted in July, 1935 with one-year-old plants from pots, and well watered. They were then protected from rain. The pF rose gradually from pF 2·0 on 22nd July to pF 2·82 on 23rd August, when slight wilting was observed in one or two plants after sunny periods. The plants recovered during the night. This continued till 29th August when pF was 2·84. On 29th and 30th August water corresponding to a total of 1 inch of rain was added, reducing the pF to 1·8. The pF again gradually rose, reaching pF 2·83 on 24th October. No wilting was observed. It is noteworthy that the soil took thirty-two days to dry from pF 2·0 to pF 2·82 between 22nd July and 23rd August, but on the second occasion, from 2nd September to 24th October, it took fifty-two days. This is a fair measure of the decreased transpiration and evaporation. Drying continued until 11th November when the soil reached pF 2·91 and this was maintained until 29th November, still without any evident wilting. After this water was added. The measurements given above refer to one of the frames. The other frame gave very similar measurements, except that it only reached pF 2·83 on the second drying before water was added. The mean relative humidity in the screen from 22nd July to 23rd August was about 72 per cent., and from 2nd September to 24th October it was about 83 per cent. The soil in the frames was a light loam, and that in the pots was similar but with the addition of a small quantity of sand and leaf mould. The moisture equivalents were 16·5 per cent. for the frame soil, and 13·2 per cent. for the pot soil.

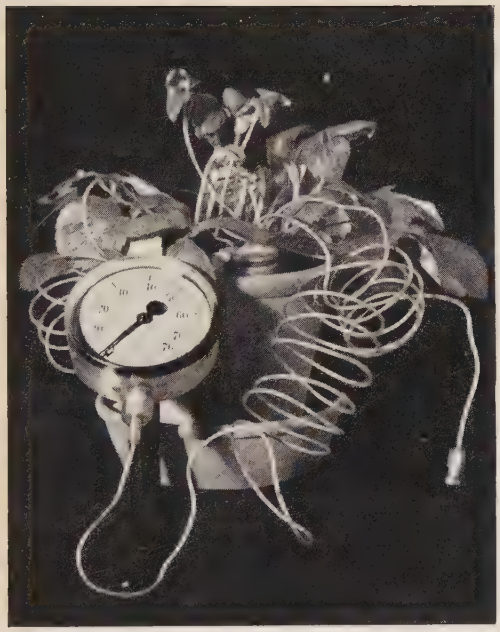

Fig. 4.

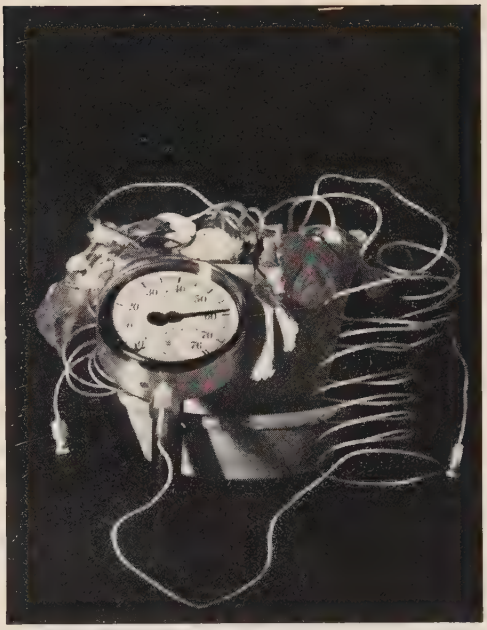

Fig. 5.

Figs. 4 and 5. Royal Sovereign Strawberry plant in pot with moisture meter.

Fig. 4, August 16th. Soil saturated, suction force nil.

Fig. 5, August 20th. Soil dried to pF 2·91 (60 cm. Hg). Plant wilting. Water was added after photographing. Next morning, August 21st, the reading was 7·2 cm.

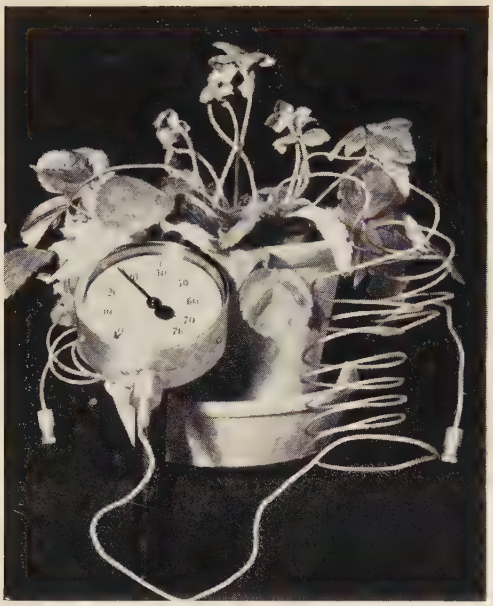

FIG. 6.

August 22nd. 10.15 a.m.
pF 2·59 (29 cm. Hg). Plant turgid.

FIG. 7.

August 23rd. 9·15 a.m.
pF 2·78 (45 cm. Hg). Slight wilting.

FIG. 8.

August 23rd. 4.30 p.m.
pF 2·82 (49 cm. Hg). Further wilting.

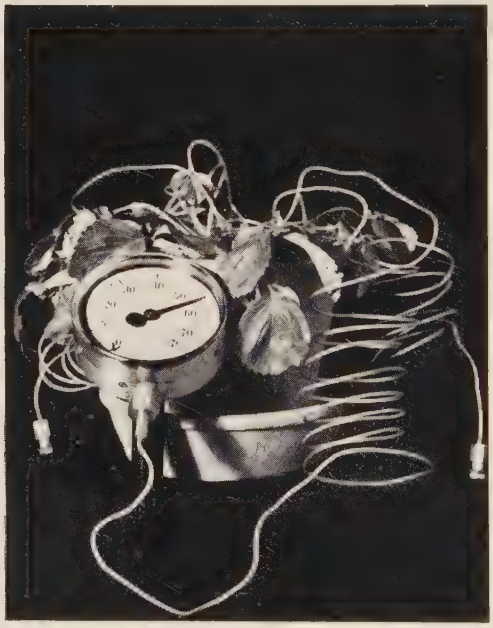

FIG. 9.

August 24th. 9.10 a.m.
pF 2·87 (56 cm. Hg). Severe wilting.

Discussion.

The above experiments show that strawberry plants in pots indoors will wilt severely between pF 2·8 and 2·9, as shown by the moisture meter, both in August and November ; whereas in a frame out of doors they show but slight and temporary wilting at pF 2·8 in a hot dry August, and no wilting even at pF 2·9 in damp November.

The conditions probably represent two extremes—the pot plants sappy, with restricted root systems in sandy potting soil and drying from pF 2·0 to pF 2·8 in fifty-five hours, and the frame plants harder, with a larger root range in light loam soil, and taking thirty-one days to dry from pF 2·0 to 2·8 in July-August, and fifty-one days in September-October. It is not possible from the above experiments to determine the importance of each of these factors—leaf, root, soil and rate of drying—separately, but doubtless each has affected the result.

It has already been shown (2, 3, 4) that the movement of soil water becomes very slow at a high pF. These experiments therefore strengthen the suggestion that under rapid drying conditions a local drought condition may be set up around the rootlets, so that a plant may become short of water while the pF of the bulk of the soil is well below the standard " permanent wilting point ". This also agrees with the findings of Maximov (1).

It must be remembered that although pF 2·8 is well within the range of the meters used, pF 2·9 is approaching the upper limit which they can measure. Any increase of pF beyond this limit does not cause the needle to rise further. Also the lag mentioned earlier in this paper is exaggerated at high pF values, especially if there is a considerable quantity of air inside the porous pot. It is therefore possible that the meter reading may lag behind the soil pF under very rapid drying conditions. The rate of drying in the frames is not fast enough to cause this error to be dangerous, but in the pots it may be that the pF indicated by the meter is somewhat lower than that of the soil at values above about pF 2·7. It is rather difficult to estimate the size of this possible error, but on account of its existence it is suggested that further work is required before it can be stated that the pF indicated by the meter under such conditions shows precisely the actual soil pF.

It is hoped to carry out such experiments shortly.

Conclusions.

In growing plants it is undesirable that wilting should take place, for it is clear that it must check them appreciably. These preliminary experiments suggest that strawberries in pots in a greenhouse approach the danger point at pF 2·7 (37 cm. Hg) as shown by the meter, and the optimum growth is probably obtained considerably below this value.

In the field strawberries are likely to be subjected to conditions somewhat between those quoted for the pot and for the frame plants—since the latter were well protected from wind, and partly shielded from the hottest sun. It is therefore likely that at least a check is experienced at suction forces exceeding pF 2·8 (47 cm. Hg) in summer. This pF can be exceeded in the field even under English conditions. In fact temporary wilting of strawberries in the field is fairly often seen, and very serious damage of this nature was noted at East Malling from the 26th June to the 1st July, 1935. The commercial possibility of artificial irrigation of strawberries in England may, therefore, be worth investigation.

Acknowledgments.

The writer expresses his grateful thanks to Dr. R. K. Schofield of Rothamsted, for reading this paper and giving valuable criticisms, and also for determining the moisture equivalents of the soils used in the experiments. Figs. 2 and 3 are reproduced from a former paper by kind permission of the Editors of the *Journal of Agricultural Science*.

Summary.

1. A summary is given of previous papers on a soil moisture meter which measures the suction force or pF of the soil, over the range from saturation to about pF 2·9, by means of a porous pot buried in the soil and connected with various special fitments to a vacuum gauge. The pF scale, introduced by Schofield (5) shows the logarithm of the suction force in centimetres of water. The suction values in centimetres of mercury corresponding to pF 2·0, 2·7, 2·8 and 2·9 are therefore 7 cm. Hg, 37 cm. Hg, 47 cm. Hg and 59 cm. Hg, respectively.

2. The soil both at 1 ft. and 3 ft. deep in a grass orchard in Kent dried to pF 2·9 during each of the dry summers 1933, 1934 and 1935.

3. Experiments with strawberries in pots and frames containing moisture meters are described. The plants in pots wilted between pF 2·8 and 2·9 (as shown by the moisture meter), at a drying rate of from pF 2·0 to pF 2·8 in fifty-five hours. The plants in frames only showed slight wilting at pF 2·8 in August, and no wilting at pF 2·9 in October. The drying rate from pF 2·0 to pF 2·8 in the frames was slower, viz. thirty-one days in July and August and fifty-one days in September-October.

4. It is suggested tentatively that for optimum growth the soil for strawberries in pots should be kept below pF 2·7 and for strawberries in the field below pF 2·8. To keep the soil of a strawberry field below pF 2·8 would necessitate artificial irrigation in a dry summer in England.

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(1) Maximov, N. A. "The plant in relation to water," p. 246. Allen & Unwin, 1929.

(2) Rogers, W. S. "A Soil Moisture Meter depending on the 'Capillary Pull' of the soil, with illustrations of its use in fallow land, grass orchards and irrigated orchards." Journal of Agricultural Science, 1935, **25,** 326-43.

(3) ——— "Root Studies, IV. A method of observing root growth in the field; illustrated by observations in an irrigated apple orchard in British Columbia." E. Malling Res. Sta. Ann. Rep. for 1933 (1934), 86-91.

(4) ——— "Root Studies, VI. Apple roots under irrigated conditions, with notes on use of a soil moisture meter." Journ. Pom. and Hort. Sci., 1935, **13,** 190-201.

(5) Schofield, R. K. "The pF of the water in soil." Trans. Third Int. Cong. of Soil Sci., **2,** 1935, 37-48.

WEATHER CONDITIONS DURING 1935

By H. C. CHAPELOW and H. M. TYDEMAN

THE weather conditions experienced in this locality during the past year might be characterized as variable. Outstandingly the most important meteorological event of the year from the point of view of the fruit grower was the disastrous frost which occurred during the night of the 16th of May and which either completely destroyed or greatly reduced the blossoms and young fruits of most varieties of fruit trees. May was, in general, a cold month with frequent ground frosts and cold northerly winds.

The mean temperature of the air within the screen was 49·7 degrees. The highest recorded temperature of the year was 85 degrees which occurred on the 7th August and the lowest of 17 degrees was recorded on December 24th. The mean temperature of the year was only 0·2 degrees below the twenty years' average at this Station. With the exception of May which was cold throughout, the remaining months of the year have been mild. In particular, the weather throughout the autumn has been warm and fine and it only gave place to cold frosty conditions three weeks before Christmas. Contrary to expectation, milder conditions supervened almost immediately before Christmas Day and the conditions were warm and wet during the closing days of the year.

The total rainfall for the year was 30·36 inches, 5·23 inches more than the average rainfall here during the past twenty years. The distribution of the rainfall during the year was somewhat exceptional. January, March and July were very dry months, March, in particular, having rather less than one-tenth of the average quantity of rain. This deficiency was, however, almost completely made up by the end of April which was a very wet month. From the beginning of September until the end of the year rainfall was above the average, and during the latter part of this period, conditions were so wet that serious flooding had resulted in many parts of the country.

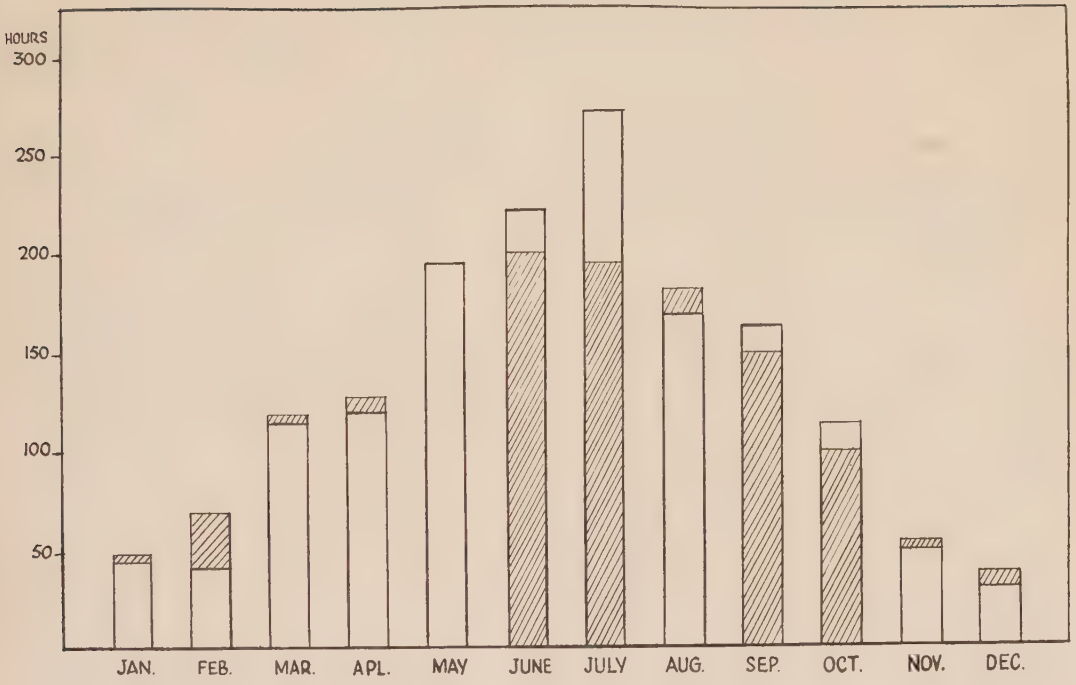
Sunshine was plentiful throughout the year. The total amounted to 1572·4 hours. This is more than 90 hours above the average annual sunshine here during the past 20 years. Sunshine was recorded on 293 days. With the exception of February, which was notably deficient in sunshine, the amount of sunshine recorded during all the earlier months of the year was about normal. From the beginning of June until the end of October, however, sunshine was considerably above the average. July in particular was a very sunny month with an average of nearly nine hours sunshine per day, and it exceeded the 20 years' average by two and a half hours per day.

Thunderstorms were not of great frequency during the year, and it is a little curious that one of the most severe was recorded quite early in the year, on the 25th of February, accompanied by violent hail. Several periods of severe gale were recorded and one of the most severe, on the night of the 16th of September, did much damage to the leaves of fruit trees and brought down considerable quantities of fruit. Gales were also unusually prevalent during November and December.

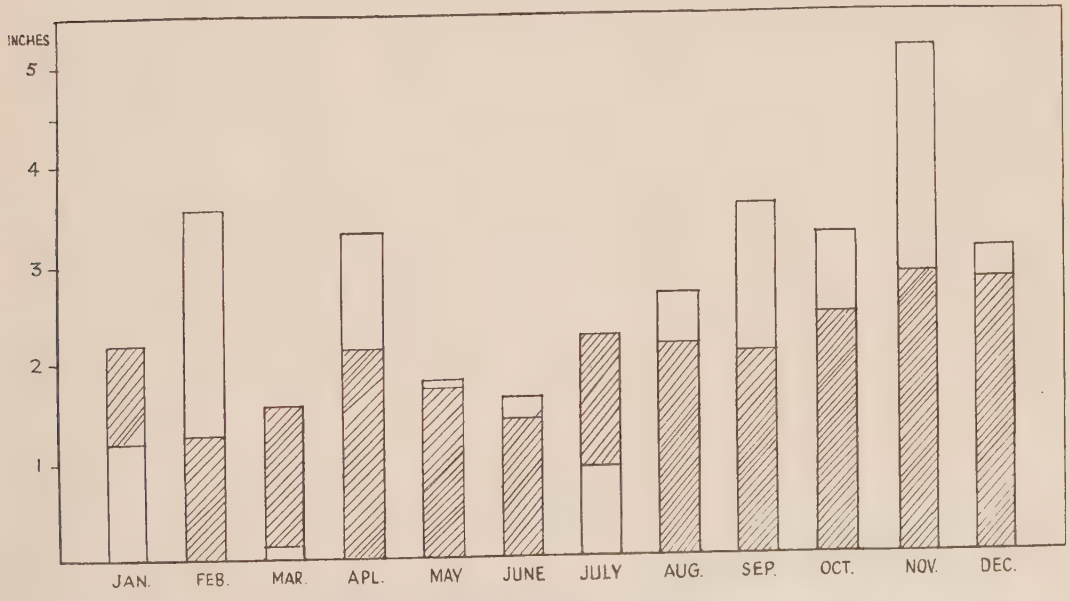
SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1935

	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	20 years' average.	Total hours.	Average per day.	20 years' average.	4 inches.	8 inches.	2 feet.
January ..	44·0	34·6	53	24	39·3	16	1·19	0·22	2·20	44·2	1·43	48·3	39·1	40·1	42·5
February ..	47·8	36·9	57	28	42·3	8	3·56	0·85	1·26	42·2	1·51	69·3	39·8	40·5	41·6
March ..	50·3	34·8	65	26	42·5	15	0·15	0·06	1·57	116·0	3·59	119·3	40·7	41·3	42·7
April ..	53·8	40·3	61	30	47·1	4	3·31	0·38	2·13	121·9	4·06	128·1	46·4	46·1	47·1
May ..	58·6	41·7	72	25	50·1	6	1·82	0·74	1·73	196·8	5·70	196·0	51·1	50·1	51·4
June ..	68·4	51·6	83	38	60·0	0	1·63	0·23	1·40	223·7	7·46	200·9	60·4	59·0	58·6
July ..	74·7	52·7	83	39	63·7	0	0·94	0·41	2·24	273·1	8·81	191·9	66·3	65·7	65·7
August ..	73·5	49·0	85	39	61·3	0	2·67	0·92	2·16	194·2	6·26	183·4	63·7	63·5	64·8
September ..	65·7	49·0	71	35	57·3	0	3·57	0·61	2·06	164·0	5·47	150·4	57·7	57·8	59·4
October ..	57·3	41·9	62	27	49·6	7	3·26	1·01	2·47	114·7	3·70	99·2	48·7	49·4	52·6
November ..	50·9	39·0	62	26	44·9	12	5·15	0·95	2·86	50·5	1·71	54·5	44·0	45·5	47·7
December ..	43·1	33·8	52	17	38·4	21	3·11	0·41	2·80	31·1	1·00	37·7	37·2	38·7	40·4

TOTAL SUNSHINE IN HOURS.



TOTAL RAINFALL IN INCHES.



Diagrams showing Total Sunshine and Rainfall during 1935 as compared with 20 years' average. Shaded portion 20 years' average.

STATISTICS AND RECORDS

SPRING FROSTS AT EAST MALLING, 1915-35

By T. N. HOBLYN

THE widespread interest in the protection of fruit blossom from frost damage aroused by the disasters of May 1935, makes it essential to know how often such frosts have occurred in the past and are likely to recur. It has been considered worth while therefore to examine the meteorological and blossoming records accumulated at this Station to find out how often frosts have occurred during the spring months and as far as possible how much damage was done.

In Fig. 1 the records of minimum air temperature in April and May recorded in the screen at East Malling—in Great East Plantation—from 1915 to 1935 are summarized. This diagram shows the number of occasions on which each reading of the thermometer in degrees Fahrenheit occurred on each day during the two months.

Thus in twenty-one years on 1st April the reading was 20° F. on one occasion, 28° F. once, 30° F. three times, 31° F. twice and so on for each day. The final column gives the total number of occasions that each reading occurred out of the whole 1,262 recordings.

In discussing these minimum temperatures it is as well to be quite clear as to their meaning. They are recorded by a minimum thermometer placed in the screen at 3 ft. 6 in. from ground level. The screen is placed on the Meteorological Plot which is situated in the open, well away from neighbouring trees. They should not be confused with the readings made at ground level on grass which are usually several degrees lower at this time of year. The temperatures are always recorded at 9.0 a.m. Thus a reading recorded on the 17th is the lowest temperature reached during the previous twenty-four hours—probably just before sunrise on the morning of the 17th.

The actual daily mean temperature for the twenty-one year period is shown on the diagram by the broken line, and it is evident that while there is a gradual rise in minimum temperature, there are considerable fluctuations from day to day.

It is of interest to test the available data to determine whether in fact any of these fluctuations are significant ; that is to say, whether there are any grounds for supposing that any particular period is indeed colder or warmer than another, apart from the gradual increase in temperature associated with the advance of the season.

A straight line was therefore fitted to the data and is shown as a continuous line in the diagram. The statistical significance of the deviations from this line were then tested by the method described by Fisher (1) for testing the straightness of a regression line. It was found that in fact the straight line well represented the data, and that none of the deviations from it were inconsistent with the hypothesis of a lineal increase in temperature during the period.

It may be concluded therefore that, if there are any particular cold or warm periods during these two months, the data accumulated so far at East Malling are not sufficient to establish them.

FREQUENCY OF OCCURRENCE OF MINIMUM AIR TEMPERATURES AT EAST MALLING
ON EACH DAY IN APRIL AND MAY 1915 – 1935

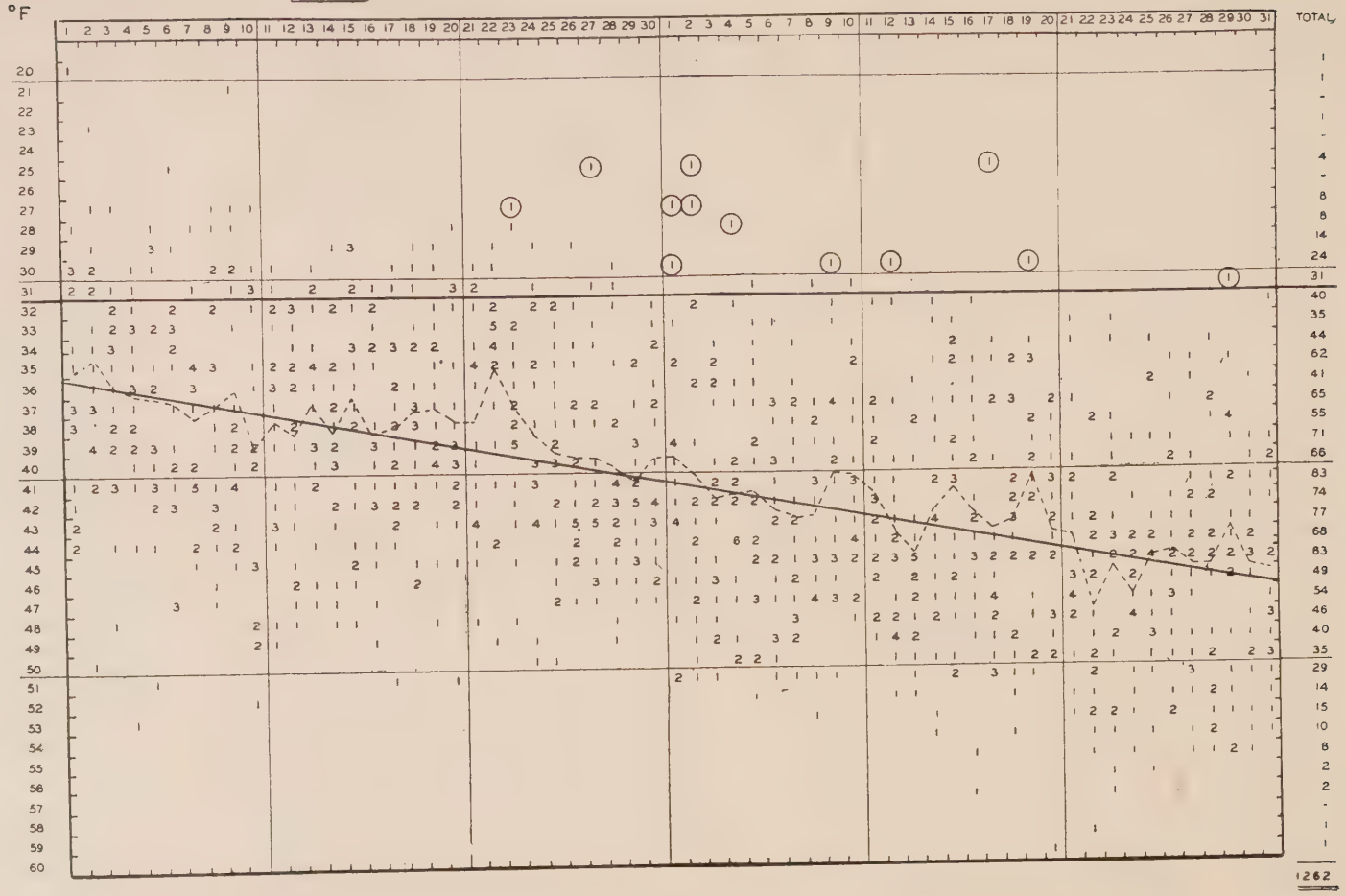


FIG 1

Frequency of Frosts.

For the purpose of this paper it will be assumed that a frost has occurred if the temperature falls below 32° F. The readings are made to the nearest degree so that if the reading is 31° F. it will be assumed that there has been one degree of frost.

Apart from the frosts here recorded, there have been, of course, a number of ground frosts ; further, owing to the absence of wind within the screen, it is possible that, with a cold wind blowing, the air temperatures may be lower outside than those recorded. However, it seems probable that, unless a frost is recorded in the screen, it is not sufficient to affect the blossoms of fruit trees—although small fruits which are nearer the ground may be affected.

During the whole period frosts were recorded on ninety-two occasions, seventy-nine in April and thirteen in May, the latest being one degree on 29th May, 1927. It will be seen at once that the frost of 17th May, 1935, when seven degrees of frost were recorded in the screen and twelve degrees on grass, stands practically alone both for lateness in the season and severity. Previously the most severe May frost recorded was on 2nd May, 1929 (7 degrees), this being only approached in severity by the cold spell of 1st and 2nd May, 1927, when readings of 27 degrees were recorded on two successive nights.

In late April the most severe frosts recorded were five degrees on 23rd April, 1933, and seven degrees on 27th April, 1927.

Effect on Fruit Blossom.

Prior to 1925 there is no record of damage to fruit blossoms by frost. The only severe frosts recorded after the middle of April were on the 23rd and 26th April, 1917, when readings of 28° and 29° F. were registered. In this year, however, there was little fruit other than strawberries at the Station and no damage was occasioned.

In assessing the damage done, it is necessary to take into consideration the time of blossoming of the various fruits concerned and the effect upon it, if any, of the temperatures earlier in the year.

In Fig. 2 the weekly mean maximum, minimum and grass temperatures are shown graphically for the months of March, April and May in seven seasons, 1925-9, 1933 and 1935. The years prior to 1925 and 1930, '31, '32 and '34 are not included as in them no late frosts occurred.

In this diagram the approximate dates when trees were in full bloom are indicated for four fruits, apples, pears, plums and black currants. Accurate information of the blossoming dates of pears in 1925, '26 and '27 are, however, not available. Some information concerning other fruits is available, but as it is not complete it is not included in the diagram.

These seven years will now be considered in detail.

1925.

For the most part March in this year was a cold month, frosts were recorded in the screen eleven times, and nineteen times on the ground, and it was not until April that the weather became warmer. In consequence the blossoming season was late and plums were not in full blossom until the third and fourth weeks of April. Currants blossomed for the most part about the second week in May, Baldwin being a week earlier than the rest, and apples did not bloom until the third week in the month.

Apples set a uniformly good crop and were unaffected by frosts. Baldwin and Goliath black currants set heavy crops, but French and Boskoop were rather poor.

MEAN WEEKLY TEMPERATURES AT EAST MALLING IN SPRING IN CERTAIN SEASONS.

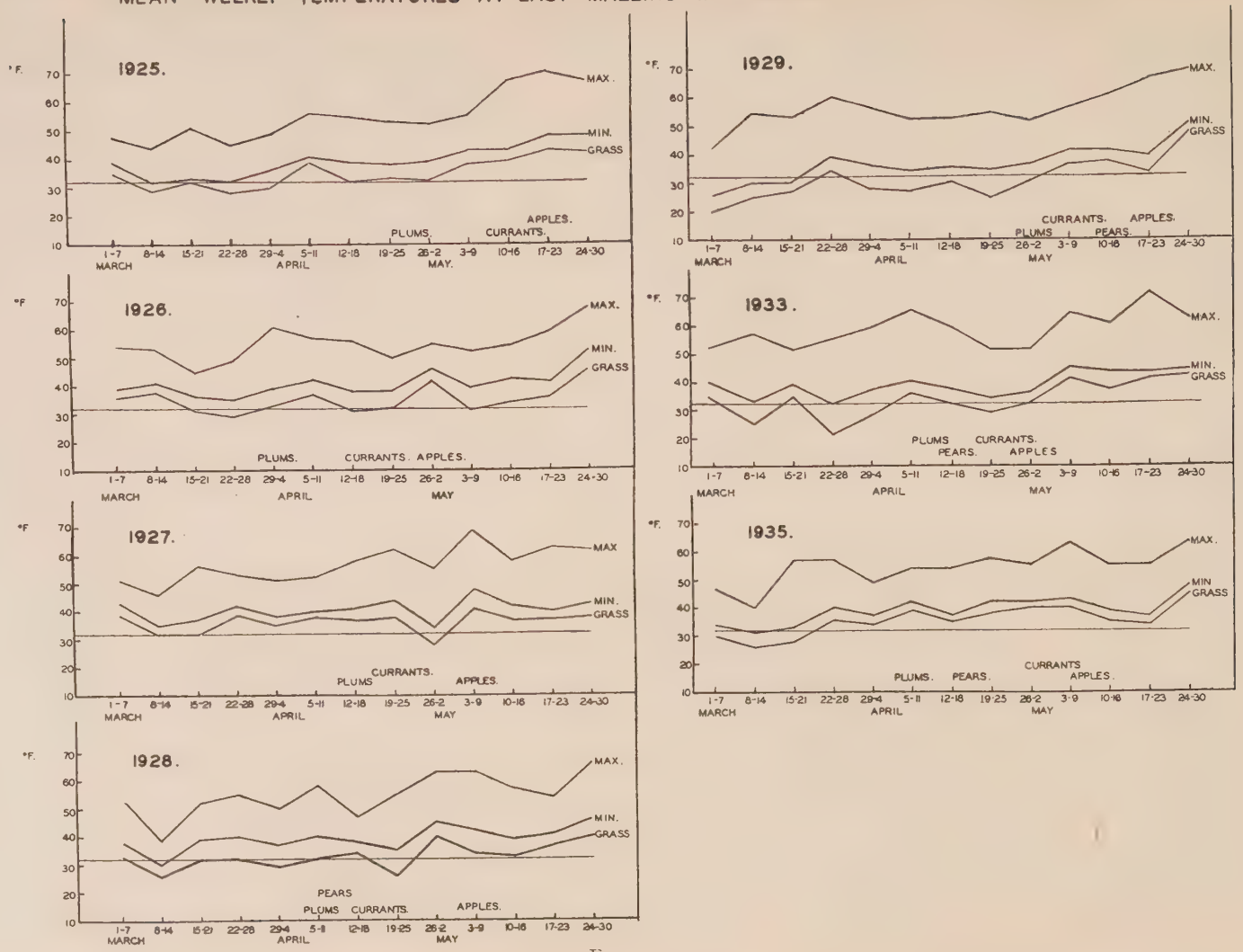


FIG 2.

This, however, cannot be attributed to frost. The Annual Report for the year states, on the other hand, that the set of plum blossom was disappointing. Here temperature may have played a part, since several ground frosts were registered when the trees were in full bloom, the most severe on 22nd April, when a frost was also recorded in the screen. It may be noted, however, that an inch of rain fell during the last ten days of the month and this may have discouraged pollination by insects.

1926.

Apart from a rather cold period in the middle of the month, March, 1926 was considerably warmer than in 1925 and the blossoming season was fully three weeks earlier. Plums were in full bloom by the 1st April, black currants a fortnight later, and apples before the end of the month. This proved of no advantage to the majority of fruits. Plums suffered least, for a warm spell with several hot sunny days at the beginning of the month enabled them to set a fair crop, which survived the subsequent bad weather. Black currants were uniformly poor this year and this is hardly surprising. Four frosts were recorded during the week in which the majority were in full bloom, the earlier Baldwin this time feeling the full force of an eleven degree ground frost on 11th April. The second half of the month was wet and sunless, there being over $3\frac{1}{2}$ inches of rain during the last fortnight. This was followed by unfavourable weather in May, during the first fortnight of which there were eight ground frosts, the most severe being on 9th May, when a frost was also recorded in the screen. The apple blossoming season was in consequence very prolonged. The Annual Report records that " during the forty-four days in which Lane's Prince Albert Apple was blossoming 6·33 inches of rain was recorded " ; so that it is hardly surprising that there was practically no crop from this variety.

Earlier varieties of apples were less unfortunate, but most of the later blossoming sorts were a failure.

1927.

March and the first part of April this year were generally warm ; but the rather dull weather in the beginning of April delayed the blossoming of plums until the middle of the month. They were followed by the currants about a week later. Then, however, came a cold period. On 27th April the screen temperature fell to 25° F. and this was followed by readings of 27° F. on the 1st and 2nd May.

This frost almost entirely destroyed the crops of plums and pears and reduced the crops of currants, gooseberries and even raspberries. The apple blossoming must have been delayed by this cold spell and most varieties seem to have escaped its effects. Bramley's Seedling, however, a variety which seems to be particularly susceptible when in the green bud stage, was, with the exception of the trees on No. IX, a complete failure. It is interesting to note that the trees on this rootstock are *earlier* blossoming than those on other stocks.

1928.

In spite of numerous ground frosts in March and April this season was again an early one. Compared with 1927 plums and currants flowered a week earlier but apples were about the same time. During the season there were sixteen ground frosts in March, sixteen in April and nine in May, but in the screen only nine during the whole period. Thus, though the season was in some respects similar to 1927, the frosts were not so

severe and less damage was done. It may be noted in Fig. 2 that there is a considerably greater difference between the minimum air temperatures and those on grass than in the previous year. Nevertheless, some damage was probably done to plums, pears and black currants. Plums were variable ; Victoria carried a fair crop, but Czar was a failure. The pear crop was likewise completely destroyed and all varieties of black currants were very poor. Probably as much damage was done this season by the cold easterly winds as by frost, since, for a whole week, while plums, pears and currants were in full bloom, the wind remained in this quarter. Apples this year experienced excellent conditions and set heavy crops.

1929.

This year is included in the diagram, not because there was any damage to fruit blossom, but to show that, provided the flowering is delayed, late frosts can be experienced without any damage resulting. The season was in fact an exceptionally late one. The weather remained cold right up to the first week in May. In March the average weekly minimum temperature in the screen remained below freezing point until the last week, and was only just above it all through April, in which month nineteen ground frosts were recorded. Seven degrees of frost were recorded in the screen on 2nd May, and four degrees on 4th May.

Owing to this *continuous* cold weather, even plums were not in bloom until the first week in May, and during the next three weeks almost all varieties of fruit came into flower. The weather during this period was mild and sunny and uniformly heavy crops were obtained.

1933.

In contrast to the season just described 1933 was an early blossoming season. Numerous ground frosts in March were not reflected in the air temperatures ; and following a warm spell in the first week, plums and pears were in full bloom by the middle of April, currants in the third week, and apples by 1st May.

The warm spell, however, was not maintained, and severe ground frosts were registered on 14th, 15th, 19th and 22nd April. Frosts were also recorded in the screen on all these days. Pears and black currants were severely affected and to a less extent plums, gooseberries and the early blossoms of strawberries. Nevertheless some of the later varieties of plum bore heavy crops. Apples were late enough to escape the main effects of the frosts. Bramley's Seedling was in general in its " off " year, but once again, even though the flowers were in the green bud stage, many of the fruits which set had the typical " medlar eye " associated with frost damage to this variety.

1935.

The past season is a sufficiently recent and painful memory, and there is no need to dwell upon it here. An account of its disastrous effect upon our crops will be found elsewhere in this Report. For plums and pears the season was an early one ; but the cold winds in early May kept the apples back until the middle of the month.

Up till that time plums, pears, cherries, gooseberries and red currants had all set well. However, the severe frost on the night of the 16th-17th May effectively precluded any hope of harvesting a crop in the majority of cases. An account of the crops which did survive will be found in the farm report.

Conclusion.

To sum up these notes, damage to fruit plants due, if not entirely to frost, to unfavourable weather conditions during the blossoming period, has been of some economic importance in six years out of twenty-one at this Station. It is possible that on one further occasion (1917), some damage might have been done had there been any fruit trees old enough to bear blossom.

Plums have been affected to a greater or lesser extent on five occasions, pears four times, black currants five times, and apples four times. In the last case Bramley's Seedling has been the sufferer in two seasons when most other varieties have escaped injury.

In only one season (1935) has the frost been so severe as to affect every crop on the Station.

On most of these occasions the damage has been done by a cold spell in the third or fourth week of April, or very early in May. This is evidently the most dangerous period, especially if the season is an early one.

Summary.

1. The records of Minimum Air Temperature at East Malling during the months of April and May are summarized for the twenty-one year period 1915-35.

2. The frosts which occurred during these months are commented on and their effect upon fruit blossoms analysed.

3. It is shown that damage to fruit plants of economic importance due to unfavourable weather conditions during this period has occurred in six seasons out of twenty-one.

Reference.

(1) Fisher, R. A. Statistical Methods for Research Workers, **8**, 5th edition. Oliver and Boyd.

PHYSIOLOGY

A NOTE ON THE MOISTURE CONTENT OF THE STEMS OF DIFFERENT ROOTSTOCKS

By M. C. VYVYAN

Introduction.

In the course of an experiment, still in progress, on the growth rates and leaf : stem : root ratios in young trees of different scion-stock combinations, determinations were made of the fresh weights and dry weights of the residual piece of stock stem below the bud union, and some rather interesting differences in moisture content were found between different stocks ; these are summarized in Tables I-III.

Material.

There were eight kinds of trees, comprising all possible combinations of the two scion varieties, Cox's Orange Pippin and Lane's Prince Albert, and the four rootstocks, Nos. I, II, IX and XII. Determinations of moisture content have been made on seven different occasions, four on trees of Series I, which were planted as maidens in the spring of 1934, and three on those of Series II, which were planted as maidens in the spring of 1935. Six trees of each scion-stock combination were used at each determination.

Results.

The moisture contents, expressed as percentages of the dry weight, of the residual piece of stock stem below the bud union, after removal of the scion and the roots, are given in Table I. In every column the values for the stock No. II whether under Cox's or Lane's, are lower than those for the other stocks. In most cases the difference is greater than the value of the " Significant Difference ", given at the base of the column, which means that the chances are more than 20 to 1 against the difference having arisen by mere chance.

In Table II the twelve trees on each stock, six under Cox's and six under Lane's, have been grouped together. Owing to the larger number of trees in each group, the values for the Standard Errors, and Significant Differences are smaller. The values for No. II are now in every case significantly lower than those for any other stock. In April, but not at other times in the year, the values for No. I are significantly higher than those for Nos. IX and XII.

In Table III, the trees have been classed, according to scion variety, into two groups of 24. There is one isolated case of a Significant Difference, that of Series I in April, 1935, but, taking the table as a whole, there seems no evidence that the scion variety has influenced the moisture content of the piece of stock stem.

Moisture content of residual piece of stock stem after removal of scion and roots, expressed as a percentage of dry weight.

TABLE I.

SCION-STOCK COMBINATIONS.

Series	I.	I.	I.	I.	II.	II.	II.
Scion/Stock.	April, 1934.	August, 1934.	November, 1934.	April, 1935.	April, 1935.	August, 1935.	December, 1935.
Cox/I. ..	92·97	89·16	81·33	89·97	97·29	91·13	83·44
Cox/II. ..	76·45	83·78	73·36	72·05	81·46	85·06	75·07
Cox/IX. ..	88·54	87·35	79·45	85·70	92·90	88·99	83·08
Cox/XII. ..	87·48	86·24	80·93	84·77	91·18	87·91	83·29
Lane/I. ..	92·92	94·69	81·20	88·01	90·95	91·14	82·29
Lane/II. ..	81·36	81·87	72·19	73·89	74·30	86·21	70·13
Lane/IX. ..	87·43	90·28	78·68	85·29	89·57	89·19	82·94
Lane/XII. ..	86·48	90·33	82·66	86·28	89·79	91·61	85·72*
S.E.	1·432	3·311	1·438	1·418	1·298	1·915	·916
Sig. Dif. ..	4·05	9·38	4·07	4·01	3·67	5·42	2·59

* These represent a second batch of Cox/XII. as there was a shortage of Lane/XII.

TABLE II.

GROUPED ACCORDING TO STOCKS.

Series	I.	I.	I.	I.	II.	II.	II.
Scion/Stock.	April, 1934.	August, 1934.	November, 1934.	April, 1935.	April, 1935.	August, 1935.	December, 1935.
I.	92·95	91·93	81·26	88·99	94·12	91·14	—
II.	78·90	82·82	72·77	72·97	77·88	85·13	—
IX.	87·98	88·82	79·07	85·50	91·23	89·09	—
XII.	86·98	88·29	81·80	85·53	90·48	89·76	—
S.E.	1·012	2·341	1·017	1·003	·918	1·354	—
Sig. Dif. ..	2·86	6·62	2·89	2·84	2·60	3·83	—

TABLE III.

GROUPED ACCORDING TO SCIONS.

Series	I.	I.	I.	I.	II.	II.	II.
Scion/Stock.	April, 1934.	August, 1934.	November, 1934.	April, 1935.	April, 1935.	August, 1935.	December, 1935.
Cox	86·38	86·63	78·77	83·12	90·71	88·27	—
Lane	87·03	89·29	78·68	83·37	86·15	89·29	—
S.E.	·716	1·655	·719	·709	·649	·958	—
Sig. Dif. ..	2·02	4·68	2·03	2·01	1·89	2·71	—

Discussion.

The consistently lower moisture content of No. II is of some interest, as it may be connected with the lower conductivity of its wood, reported by Dr. Knight in 1926 (2). Moreover there is a tradition that the wood of this stock tends to be rather dry. Although the difference is not as interesting as it would have been if it had occurred between two stocks of extreme in vigour and precocity, such as Nos. IX and XII, any physiological difference found between stocks is of value on account of the light it may throw on the question of stock effect on scion. The cause of the difference will be further investigated. It may lie in a difference in the relative amounts of bark and wood, which have different moisture contents. Or it may be that either the wood or the bark has a different specific gravity in different stocks. There is just a possibility that the differences were due to the amounts of bark removed from the piece of stock stem when the roots were cut off; this is unlikely, however, as more bark is removed from a No. I, whose roots are distributed over the whole surface, than from the basally rooting No. II. As bark is wetter than wood this should make No. I drier than No. II. If the values given in the tables had been worked out by the ordinary method of dividing the moisture for each tree (multiplied by 100) by the corresponding dry weight, they might have been due merely to differences in tree size. For if heavy trees tended to be drier than light trees and those on No. II tended to be heavier than those on other stocks, these would appear to be drier too. To eliminate this possibility the values were calculated by the method of covariance, described by Fisher (1). If the differences had been due to tree size, the values found by this method would have been the same for each stock.

Summary.

1. The moisture content of the residual piece of stock stem below the union has been examined in four apple stocks under two scion varieties.

2. No. II had consistently the lowest value, and No. I, in spring, the highest.

3. It is suggested that the low value found for No. II may be connected with the low conductivity of that stock.

References.

(1) Fisher, R. A. Statistical Methods for Research Workers, 5th edition. Oliver and Boyd, London, 1935.

(2) Knight, R. C. "Programme of Research in Physiology." E. Malling Res. Sta. Ann. Rep. for 1926 (1927), pp. 53.

BIOCHEMISTRY

LEAF INJECTION

By W. A. ROACH

In the spring of 1935 a small pear tree grown in a pot in a glasshouse by Mr. H. M. Tydeman for breeding purposes, produced foliage of a golden-yellow colour almost completely lacking in green. The fruit which had set as a result of experimental crosses did not develop normally and it was feared that the tree and the fruit, which was valuable from an experimental point of view, would die. An attempt was therefore made by injection to discover whether the tree was suffering from a deficiency disease and if so to cure it.

What little green there was on the leaves occurred in thin bands close to the main veins. This distribution of green in an otherwise yellow leaf was seen on the chlorotic peach tree which was proved to be suffering from faulty iron uptake and which formed the subject of a note in the last year's Annual Report (2) ; the same distribution of green, however, has been observed in plants suffering from shortage of other substances. At that time there was no reason to suspect the soil here of being unsatisfactory in respect to iron ; it was thought possible, therefore, that the effects of many substances would have to be tested before the correct one would be found. The shoot-tip method of injection described in the last year's Annual Report (2) would hardly be applicable to this problem because the tree had only a small number of shoots, suitable for this type of injection, which were not dangerously close to a fruit. Hence it was decided to experiment on single leaves instead of shoots. Each solution to be tested was contained in a small glass tube (about $1\frac{1}{8}$ inches diam. by $1\frac{1}{2}$ inches deep), which was supported, on a shoot or branch, with plasticine. Less than $\frac{1}{2}$ inch was cut from the tip of the leaf with scissors and it was supported so that its cut end was immersed just under the surface of the liquid, as shown semi-diagrammatically in Fig. 1.

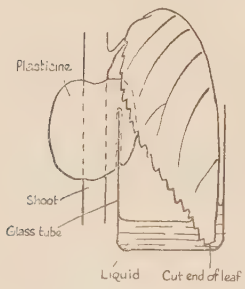


Fig. 1.

The following solutions were tested in this way :

0·1 per cent. zinc sulphate.
0·1 per cent. manganese sulphate.
0·1 per cent. iron tartrate.
0·1 per cent. copper sulphate.

These were set up at 4 p.m. on 29th April and taken off at 10 a.m. the following morning. The first three solutions had caused no appreciable damage to the leaves, but the veins of the leaf treated with copper sulphate had turned brown and there were brown spots on the leaf.

Another leaf was treated in a similar manner with 0·05 per cent. copper sulphate solution which it was allowed to absorb for twenty-four hours, at the end of which time there was slight browning of the cut surface but no other damage. None of the

leaves showed any improvement when examined five days after injection. The following notes were made eleven days after injection :

0·1 per cent copper sulphate—leaf dead and dropped and the half of each of the two nearest leaves were dead and brown.

0·05 per cent. copper sulphate
0·1 per cent. zinc sulphate
0·1 per cent. manganese sulphate
} undamaged, but no improvement.

0·1 per cent. iron tartrate—undamaged and of normal green colour.

The leaf treated with iron (ferric) tartrate appeared quite normal and healthy and was in marked contrast with every other leaf on the tree, there being no other leaf even approaching it in greenness. Iron, therefore, appeared to be the element required.

To test this conclusion and to ascertain what was a safe concentration to inject to cure the whole tree a shoot tip injection was carried out in a somewhat similar manner to that described in the last year's Annual Report (2). A vertical shoot was cut well back into the previous year's wood and a glass tube was fixed to the cut end by means of rubber tubing as shown in Fig. 2. The glass tube was filled with 0·05 per cent. iron tartrate and absorption allowed to proceed for one day. No damage became apparent and at the end of about ten days all leaves on the injected shoot became normal in colour. By cutting the shoot well back into the previous year's wood it was hoped that absorption would be about as free as through a hole drilled through the main stem and that consequently a solution that caused no damage when injected through such a cut end of a shoot might also be safely injected through a hole in the main stem. A solution of the same concentration was, therefore, injected through a hole $\frac{1}{8}$ inch diameter passing through the main stem of the tree and the injection was allowed to proceed for twenty-four hours. No damage resulted and ten days later practically every leaf on the tree had taken on a normal green colour. During the rest of the season the tree made satisfactory growth and the fruit matured normally.

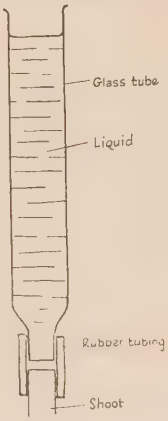


FIG. 2.

In view of this experiment and the one carried out on a peach tree and described in the last Annual Report it may be concluded that iron " shortage " chlorosis may be diagnosed by a small scale injection (either leaf or shoot) in ten days and that the whole tree may be cured by an injection through the main stem in a further ten days. In short, this type of chlorosis may be both diagnosed and cured in twenty days. Doubtless the same method is applicable to other deficiency diseases which show well-marked symptoms on the leaves.

The fact that the chlorosis was of the iron " shortage " type was unexpected, but a possible explanation was afforded by a paper by Olsen (1) which appeared about this time. His main conclusions were that the absorption of iron and its movement in the plant are rendered difficult by deficiency of organic matter if the soil is neutral or slightly acid in reaction and that this difficulty is increased by the presence of excess of phosphate. The soil in which the pear tree was growing may well have been low in organic matter as a result of leaching, which cannot be avoided entirely in a pot plant, however carefully the watering is done. It had not been given any organic manure for some years. The soil effervesced with acid and gave no colour when shaken with ammonium thiocyanate solution ; the soil reaction therefore was such as to tend to make iron uptake difficult, and the application of meat and bone manure in the past would

tend to leave an excess of phosphate after the nitrogen was partly absorbed by the tree and partly leached out. The above facts raise interesting questions in regard to many plantations which must be getting short of organic matter and in many of which light-coloured foliage may be found, a condition which cannot always be explained in terms of shortage of nitrogen, or other elements. Injection is a simple first step in investigating such questions and is being used for this purpose.

Summary.

1. The cause of a severe chlorosis in a pear tree growing in a pot was investigated.

2. Leaves were injected with various solutions by holding the cut tips of each under the surface of the liquid held in a suitable container.

3. The tree was finally cured by injecting the required liquid (a solution of ferric tartrate) through a hole passing through its main stem.

4. The results suggest that similar deficiency diseases could be diagnosed and cured in three weeks.

References.

(1) Olsen, C. "Iron Absorption and Chlorosis in Green Plants." Compt. rend. Trav. Lab. Carlsberg, 1935, **21**, 15-52.

(2) Roach, W. A. "Tree Injection—The Diagnosis and Cure of Chlorosis in a Peach Tree." A Progress Report. E. Malling Res. Sta. Ann. Rep. 1934, pp. 139-41.

TREE INJECTION, 1935 EXPERIMENTS

A PROGRESS REPORT

By J. HEARMAN, B. F. GOODMAN LEVY and W. A. ROACH

Experience prior to 1935 suggested that all risk of serious damage resulting from the injection of any of the ordinary nutrients could be avoided by using solutions of the right concentration (from 0·25 per cent. to 0·5 per cent.) and by stopping the injection at the first sign of leaf damage. Results obtained in 1935, however, show that this is not always so. The results are put on record immediately because they may be of use to other workers who are using the injection method for various purposes in many different parts of the world.

Results obtained prior to 1935.

In earlier papers (1, 2, 3) it was shown that direct damage to the leaves might result from the injection of too great a total quantity of any artificial manure or from somewhat smaller total amounts when the solution was too concentrated. Information so far available may be summarized as follows :—

1. Leaf damage became apparent, usually within a few hours and always within a day, after the injection was finished.

2. At first the damaged patches of leaf tissue looked dry or plasmolysed. Later they turned brown, became brittle and finally fell off, leaving leaves with more or less ragged edges which were often lobed like oak leaves. The patches turned brown more rapidly in wet than in dry weather.

3. In lightly damaged leaves the damaged area was confined to a narrow band along the leaf margin. It was usually widest at the leaf tip and became narrower as the distance from the tip increased. A typical leaf is sketched in Fig. 1. When the damage was more severe the marginal band was broader and from it stretched extensions between the veins (Fig. 2). When the damage was still more severe only narrow bands of tissue on either side of the main veins remained healthy. Such leaves, usually, but not always, fell within a few weeks.

4. The older leaves at the base of a shoot were invariably more heavily damaged than the younger ones nearer the tip. Often leaves at the base of a shoot have been damaged over their whole area and have fallen, and the remainder have shown all degrees of damage between this and the young ones near the growing tip, which have shown no damage at all. Even when the injection has been made through the cut end of a shoot the basal leaves have always been the most heavily damaged, in spite of being the farthest away from the place of injection.

In an experiment already described (1, p. 341) a 1 per cent. solution of potassium nitrate was injected into an apple tree. The morning after the injection the fully grown leaves on some of the branches were heavily scorched, many of them eventually falling. In spite of this immediate damage the effect on the tree by the autumn was highly beneficial, in fact, the branches which were most severely damaged immediately after the injection had, by the autumn, made the most vigorous growth. Since the damage done by a given amount of injected substance decreases as the volume of solution in

FIG. 1.

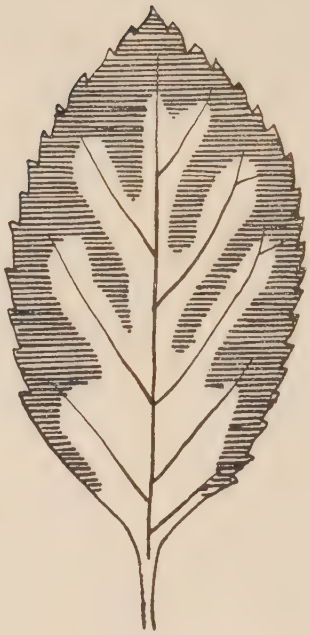


FIG. 2.

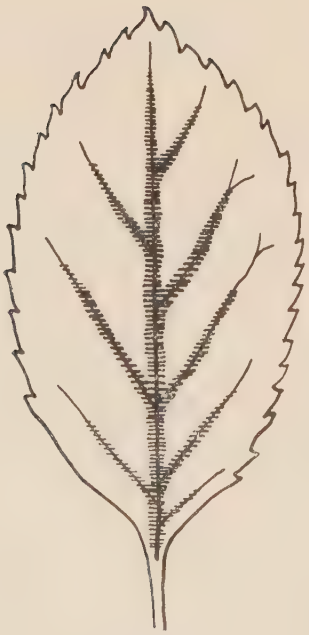


FIG. 3.

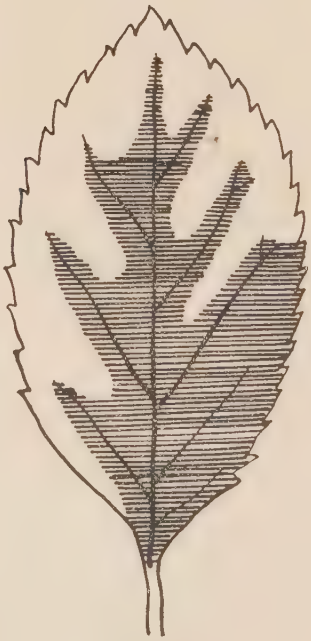


FIG. 4.

which it is injected increases (3, p. 162), it was thought that it might be possible, by injecting the same amount of potassium nitrate in a larger volume of solution, to obtain the above good effect without causing the initial severe damage; further if the right concentration were chosen, the first appearance of leaf damage might even be taken as an indication that the tree had absorbed the optimum dose. This idea was tested in 1934 and the results, which were published in the last Annual Report (2), suggested that in the absence of a better means of estimating dosage, the appearance of leaf damage might be a useful indication that the injection should be stopped.

Seeing that this "warning" damage had in the past appeared only on mature foliage, the fact that early in 1935 the leaves remained immature in appearance for some weeks after they had expanded gave rise to doubts as to whether they would react in the above manner after injection. Accordingly only a few preliminary experiments were carried out at this stage. These doubts proved to be well founded.

Appearance of Foliage before Injection in 1935.

The first leaves to expand early in the summer of 1935 were noticeably more yellow green than usual; they were thin and continued for some weeks after unfolding to appear as though they had only just expanded; in fact, these leaves which unfolded early in the season never took on a normal appearance of maturity. As the season progressed each succeeding leaf on a shoot was of a darker healthier green colour and was thicker and larger than the preceding one; the leaves expanding after midsummer appeared quite normal. In all probability the abnormality of the early foliage was the result of the severe frost of the night of 16th-17th May, when the temperature fell to 25° F. in the screen.

1935 Results.

The main differences between the 1935 results and those obtained previously are set out in the following table:—

Season.	Appearance of leaves before injection.	Damage.	
		Distribution.	Time of appearance.
Prior to 1935.	Normal.	Between veins.	Less than 1 day.
1935 Early.	"Immature."	Near veins.	More than 3 days.
1935 Late.	Normal.	Between veins.	Less than 1 day.

The damage produced by a few injections done early in 1935 differed from that produced in previous seasons in the following respects:—

1. It did not appear until at least three days after the injection, in marked contrast with the almost immediate appearance of damage in previous years.

2. The light green plasmolysed appearance, observed in previous years immediately after injection, was not noticed early in the 1935 season.

3. The damage early in 1935 spread from either side of the main veins as brown bands parallel to the veins. In lightly damaged leaves the bands were narrow (Fig. 3) and in more severely damaged ones the bands were broader. Later somewhat irregularly shaped patches, usually spreading from mid-rib to margin, became brown (Fig. 4). Many leaves turned completely brown. When many leaves were killed the

growing shoot tip was sometimes killed too. This has rarely happened in previous years.

4. All leaves, from expanded ones at the growing shoot tip to the oldest ones at the base of the shoot, appeared equally prone to damage early in 1935. This behaviour again was in marked contrast with the increase in proneness to damage with increasing age observed in previous years.

The leaves which expanded early in the season remained abnormal in appearance for the rest of the season and, however late in the season the injection was done, their behaviour was different from that observed in previous years. Leaves expanding later in the season behaved more and more like those of previous seasons as the season advanced until, at about midsummer, their behaviour was again quite normal. Thus in injection experiments carried out late in the season the leaves most prone to damage were those which expanded about midsummer and were in the middle of the shoot; the amount of damage on the other leaves of the shoot decreased with their distance, upwards or downwards, from those middle leaves.

Conclusions.

The above facts show that had leaf damage been relied on early this year as a warning when injected trees had absorbed enough fertilizer some trees would have suffered serious damage; consequently this indication cannot always be relied on. At the moment there is no satisfactory method for deciding the required dosage for a particular tree. A series of experiments designed for this purpose during the last season yielded no results; the injection was postponed until leaf damage could be relied on as a warning when enough fertilizer had been absorbed, and by this time most shoots had ceased extension growth and soil moisture was, in all probability, the factor limiting growth; consequently the injected fertilizer could have had no chance of showing its effect. Until a satisfactory method of estimating dosage is evolved all risk of doing damage by tree injections carried out in summer might be avoided by waiting until there are some fully expanded mature leaves on the tree. To make sure that any damage resulting will be shown immediately after the injection, a small scale injection of say a 1 per cent. fertilizer solution (e.g. ammonium sulphate) might be done through a shoot tip or even a leaf tip. If damage appears when the injection has proceeded for about a day and does not increase appreciably after the injection is stopped it should be safe to proceed with injections on a larger scale. In view of the fact that the unexpected 1935 results followed a severe late frost, particular caution should be exercised following such an event, especially if the leaves do not take on their normal mature appearance immediately after unfolding.

Summary.

1. The injection of a sufficiently large total dose of fertilizer to damage a tree seriously had been avoided previous to 1935 by using solutions of concentration between 1 and 0·25 per cent. and stopping the injection as soon as leaf damage became apparent.

2. Early in 1935 leaf damage did not show itself immediately, but only after a interval of three days or more after the injection; consequently sufficient fertilizer could be absorbed to cause serious damage before any warning was given.

3. This delay in the appearance of symptoms of damage was apparently due to the leaves remaining in an "immature" condition for some weeks after expansion; a mature leaf is much more prone to damage than an immature one.

4. The continued "immature" condition of the leaves after unfolding was, in all probability, a consequence of the severe frost of the night of 17th May, when the temperature fell to 25° F.

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MYCOLOGY AND BACTERIOLOGY

NOTES ON PLANT DISEASES IN 1935

By H. WORMALD

Damage Caused by Non-parasitic Agencies.

Frost Damage. The most noticeable feature of the year was the severe frost on the night of 16th-17th May, which caused widespread destruction in fruit plantations. On this Station the apple and plum crops were almost destroyed and much damage was caused to raspberries, currants and strawberries. The ovaries of the earlier flowers of strawberries were killed (as shown by the " black eyes "), but the later flowers opened undamaged ; wild strawberries in neighbouring coppices showed similar injury. The young shoots of chestnut and ash were cut back, and even oaks were affected while the foliage of early walnuts on the Station was destroyed. A leaf scorch of plum trees, noticeable towards the end of the month was also attributed to the frost.

Young Apple Trees Failing. In March, twigs of maiden trees of Cox's Orange Pippin on No. IX rootstock, received from Sussex, showed yellowish blister-like areas beneath the nodes. In some cases definite cankers were present. This condition was fairly common, for enquiries concerning similar damage were received from several localities. The swelling was a kind of intumescence and this in itself was generally not serious but in some instances it was accompanied by true canker (caused by the fungus *Nectria galligena*) when severe killing back occurred. The primary cause of the intumescences was probably unsuitable soil conditions, especially where heavy soil had become waterlogged in winter. The drought of the previous summer was probably also a contributory factor, the extreme dryness followed by excessive moisture being detrimental to the roots. The severity of the damage caused to Cox's Orange Pippin is shown by the reports received from growers. In a Sussex plantation about 10 per cent. of the Cox trees were affected while the Worcesters on the same piece of ground were not damaged. In a plantation of Laxton Superb and Cox's Orange Pippin near Paddock Wood twenty trees were dead or dying, and some young trees, again Cox's Orange Pippin, received from Cambridge, showed the same trouble, 20 per cent. of the trees being said to be affected.

Diseases caused by Parasites.

Apple and Pear Scab. Owing to the scarcity of fruit, Apple Scab (*Venturia inaequalis*) and Pear Scab (*V. pirina*) were less prevalent than usual, but in some localities where the trees had escaped the frost these diseases were severe, especially Pear Scab. One grower in North Kent who has 65 dwarf pear trees, Louise Bonne of Jersey, about 25 years old, wrote asking, " Is it the rule rather than the exception for fruit of these trees to have deep cracks in it and also to be stunted ? " ; he contemplated top-grafting the trees with another variety but specimens received showed that the trouble was a severe infection of scab so recommendations for controlling this disease were given.

Brown Rot. There was comparatively little Brown Rot in 1935 owing to the lack of fruit as a result of the May frost. One instance of Blossom Wilt followed by canker on Cox's Orange Pippin came to our notice. Brown Rot infection on an ornamental

shrub, *Pyrus purpureum*, was observed ; specimens from Seddlescombe, Sussex, showed Blossom Wilt (*Sclerotinia laxa*), and *Sclerotinia fructigena* was found on the fruit of this species at Reading (Berkshire) and at East Malling.

Although the frost destroyed the young fruits of Morello cherries it did not prevent blossom infection, and a dying back of twigs caused by infection through the unopened flowers was observed. It is to be noted therefore that even in the absence of crop there may be infected twigs on the tree as a result of such early attack and that these twigs if not removed will be sources of infection for next year's flowers.

Leaf Blotch of Medlar. In May, Medlar branches were received from near Sittingbourne showing severe damage from Leaf Blotch ; from one to four leaves were infected on every flowering shoot. The fungus causing this disease, *Sclerotinia Mespili*, is closely related to the Brown Rot fungi but this particular species is confined to Medlar so that Medlar leaves with this disease are not a source of infection for other kinds of fruit trees.

Armillaria Root Rot. The Honey Fungus (*Armillaria mellea*) continues to cause considerable loss in fruit plantations and orchards. Mr. Kent, the Advisory Officer for the County, informs us that he has met with it in many localities during the year. Black Currant roots sent in from a plantation near Paddock Wood bore numerous rhizomorphs of *Armillaria mellea ;* the grower wrote, " These are the roots from two half-dead bushes. It is spreading right in the best of them."

A " Rough Bark " Canker of Apple Trees. In November cankered branches of Bramley's Seedlings top-grafted on to Warner's King were brought in from near Maidstone. The cankers varied considerably in size ; the smallest were about two inches across but the largest were more than two feet long and completely engirdled the branches which were about three and a half inches thick. The bark was irregularly fissured except towards the end of the cankers where the fissures showed a tendency to be semi-elliptical and more or less parallel, giving a somewhat " oyster-shell " appearance. The cankers were nearly all on the Bramley's Seedling. A few were on the Warner's King (below the union of the grafted trees) and also on Lord Derby, but Grenadiers in close proximity to the Bramley's were quite free. Up to the present the disease has only been reported from one plantation. The cause of this form of cankering is not yet known. Several fungi have been isolated from the discoloured bark but there is no evidence that any one of these is the cause.

" Papery Bark " Canker. Top-grafted apple trees on this Station and in other localities have developed cankers which may be referred to as " Papery Bark ". This condition has appeared not only on trees subjected to ordinary rind grafting, but also on others which have been worked by the stub and porcupine grafting methods. In some cases this was associated with silvering of the foliage of shoots in close proximity to the grafts, suggesting that the cankering may be due to infection by the Silver Leaf fungus, *Stereum purpureum*. Although fructifications of this fungus were not found associated with the cankers on the trees, isolations on culture plates from the discoloured wood yielded cultures similar to those of *Stereum purpureum*, and on cutting off cankered branches and exposing them in the open the fructifications of this fungus developed within a few weeks on some of them.

Further evidence that this type of cankering may be caused by the Silver Leaf fungus was offered by the fact that *Stereum purpureum* was found on a double-worked pear tree that had apparently been killed by this fungus ; a " papery bark " canker

extended from the upper union for several inches down the stem while the lower portion of the stem bore numerous fructifications of *Stereum purpureum* (see p. 155).

The "Lanarkshire Disease" of Strawberries. About the middle of May our attention was called to a disease of strawberries at Westerham. In four definite patches of one plantation the plants were wilting and gradually dying. The symptoms suggested those that have been described for the so-called "Lanarkshire Disease" which is very destructive to strawberries in Scotland. The roots of the affected plants showed the "red core", and oospores of a species of *Phytophthora* were present in the tissues, symptoms which are also characteristic of the "Lanarkshire Disease". On the advice of Mrs. N. L. Alcock, who has studied this disease in Scotland, the soil of the affected areas has been treated with sodium chlorate, under the supervision of Mr. G. W. Kent, and it is hoped that the disease will be eradicated.

A Slime Fungus on Strawberry Leaves. A fungal growth found on strawberry leaves on plants growing in the greenhouse proved to be the fructifications of a slime fungus, *Physarum cinereum*, which, in its plasmodium stage had crept up the leaf-stalks to produce its fructifications on the leaflets. Although some discoloration of the leaves occurred this organism cannot be considered as truly parasitic. For illustration and further details see page 163.

A Wilting of Shoots in Nursery Layer-Rows. In former reports a wilting of shoots in stools and layer-rows of plum rootstocks is mentioned. This disease was found to be caused by *Sclerotinia laxa*, one of the Brown Rot fungi. More recently a similar wilting in layer-rows of plum, cherry and peach rootstocks has appeared on this Station but in this instance there was no evidence of the presence of *S. laxa*. On the contrary the lesions on the underground parts of the shoots bore a fungus seen as minute black dots which proved to be micro-sclerotia. Moreover when the fungus was isolated in culture numerous micro-sclerotia developed but no fructifications, so that the fungus has not yet been identified. The constant association of this organism with the wilting suggests that it is the cause of the disease but inoculation experiments for confirmation have not yet been carried out. During the summer of 1935 the loss was very severe in certain varieties of plums and cherries, 50 per cent. or more of the shoots of some of these varieties being killed.

Bacteriosis of Plum and Cherry Trees. In spite of two dry summers (1933 and 1934) which checked the leaf spot phase, Bacterial Canker continues to cause considerable loss particularly in young plantations of cherries, and enquiries concerning it have been received not only from Kent but also from Sussex, Hampshire and Devon. Very severe infection was seen in an orchard of young cherry trees at Wye; on the trees of Kentish Bigarreau in that orchard nearly every tree had one or more of its leading branches killed back. In another orchard on the same farm Black Eagle was severely infected, some of the trees being killed outright.

The foliage of Morello cherry trees on this Station showed conspicuous spotting in the spring. Numerous bacterial rods were present in these spots, and an organism was isolated which proved to be different from either of the two bacteria, *Pseudomonas prunicola* and *Ps. mors-prunorum*, which cause bacteriosis of plum and sweet cherry trees in this country. A similar spotting of the leaves was found on other varieties of acid cherries on the Station. On one of these varieties, Carnation, many flower clusters were killed; this condition again is associated with the presence of bacteria in the lesions. These diseases of acid cherries are under investigation.

Crown-gall. This disease appears to be increasing in virulence and many enquiries concerning it have been received during the year. Large galls were present on two-year-old Lord Derby and Grenadier, and maiden Worcester apple trees all on Crab rootstocks, and on maiden Williams pears on imported quince-stocks, received from a Kentish nursery. Galls on apple rootstocks No. IX were sent in from a nursery in Suffolk, the grower writing to say, " I have it slightly in stool beds of Types II and IX and also in two-year-old trees on crab and IX in the nursery." We were informed that in one district in Cambridgeshire " the nurseries are in the throes of a bad attack of Crown-gall ". One nurseryman estimated he had 10,000 trees which he would not be able to distribute on account of the trouble.

With regard to Crown-gall on rootstocks for apples and pears it may be mentioned that good results are reported on the Continent from treating the stocks with mercurial preparations. An experiment is under way at this Station to test the efficacy of applying organic mercurial dressings to the stocks on planting up.

The Himalayan Giant blackberry appears to be very susceptible to Crown-gall. Specimens showing large galls were received from near Sandwich and from Marden ; in the latter case one cane bore an almost continuous series of galls from one to three and a half inches in diameter on a length of about two feet.

In a Sussex plantation several shoots of the Black Diamond blackberry had fruiting canes bearing large galls ; the largest of these measured about two and a half inches in its largest diameter. The galls were mostly at the nodes and were growing round the base of the laterals. In three instances the gall had grown within the tissues of the cane which in consequence was split into strips united above and below the gall ; in one of these the cane above the gall was quite dead, probably killed by desiccation from exposure of the wood.

A suspected Bacterial Blight of Forsythia. Shoots of the ornamental shrub Forsythia received from Marlborough were affected by a disease which is probably a " bacterial blight ". Elongated black lesions on the shoots and spots on the leaves were found to contain numerous bacterial rods. An organism was isolated from these lesions and preliminary cultural tests suggested that it was related to, and perhaps identical with, the organism causing Lilac Blight (*Pseudomonas Syringae*). When the Forsythia organism was inoculated into young lilac shoots (cut off and kept with their ends in water in a moist chamber) definite blackened lesions resulted, which is further evidence suggesting the close relationship of the organisms.

American work on *Ps. Syringae* has shown that it is closely related to *Ps. prunicola*, which has been described as causing a shoot wilt of plums in England, and to *Ps. citriputiale* the cause of a citrus disease, and it has been suggested that the organisms described under these names may be identical. If it should prove that the organism which attacks Lilac and Forsythia can also infect the plum it appears possible that such ornamental shrubs may be sources of infection for fruit trees.

Summary.

These notes describe the chief plant diseases observed during 1935. Reference is made to frost damage and to certain disturbances in young apple trees probably caused by unfavourable weather conditions. Attention is called to a " Rough Bark " canker and a " Papery Bark " canker of grafted apple trees, the " Lanarkshire Disease " of strawberries, a wilting of shoots in nursery layer-rows of plum and cherry rootstocks, a bacterial spotting of Morello cherry leaves, a suspected bacterial blight of Forsythia, and the prevalence of Crown-gall.

BACTERIAL CANKER OF PLUM TREES IN RELATION TO NUTRITION. EXPERIMENTAL RESULTS IN SAND CULTURES

By F. H. BEARD and H. WORMALD

With an Appendix by W. A. ROACH

Introduction.

In recent years Bacterial Canker of plum trees, caused by *Pseudomonas mors-prunorum*, has been the cause of serious losses, especially in young plantations (7, 8). The control of this disease has been sought along various lines, e.g. spraying, framework grafting, avoiding pruning at those times when the trees are particularly liable to infection, and modifying soil conditions. The experiment described in the present article was designed with the primary object of ascertaining whether, by increasing or decreasing certain mineral constituents of the soil in relation to a "Complete Nutrient", it might be possible to modify the susceptibility of the trees to Bacterial Canker, and with the further object of applying these results when planning field trials for the study of soil conditions in relation to the disease.

In a previous report (9) is an account of a preliminary experiment in which nitrogenous nutrients were tested against potash; the results, though inconclusive, suggested that "under the conditions of the experiment potash had not had any restraining influence on the predisposition of the trees".

In the spring of 1932 a further trial was planned; it was decided to grow young plum trees in sand cultures with various synthetic nutrients in order to note the effect of the treatments on the general health and development of the trees, and eventually to infect the trees with *Ps. mors-prunorum* so that the size of the resulting cankers could be compared.

Plan of Experiment.

Forty-two two-year-old Victoria plum trees worked on Myrobolan A stock were planted in 18 inch pots, each filled with a weighed amount (140 lb.) of pure Bedfordshire silver sand. All drainage holes were sealed except one in the front of each pot which was fitted with copper gauze to prevent the escape of sand, whilst allowing free drainage. The pots were then plunged in the manner already described elsewhere (1) for a similar experiment with hops. The trees received weekly applications of $1\frac{1}{4}$ litres of the dilute nutrient solutions. The sand was kept moist by application of rain water as required.

The advice of Dr. T. Wallace of the Long Ashton Research Station was sought as to the best combination of nutrients for the experiment and the following were based on his recommendation:

Complete Nutrient (Cm.).

	gm.
Potassium nitrate	6·0
Calcium nitrate	1·4
Di-potassium phosphate	1·0
Calcium sulphate	2·0
Magnesium sulphate	3·0
Sodium chloride	0·5
Ferric chloride	0·4
Rain water	to one litre.

One litre of this stock solution was diluted with nine litres of rain water for application. The other solutions were obtained by substituting sodium for base-forming elements, and sulphate for acid radicals, thus :

Double Nitrogen (2N).

As Cm. but with sodium nitrate 6·5 gm. in addition.

Low Nitrogen (–N).

As Cm. but the potassium nitrate replaced by 5·25 gm. potassium sulphate, and the calcium nitrate by 1·5 gm. of calcium sulphate.

Potassium reduced to half ($\frac{1}{2}$K).

As Cm. but potassium nitrate replaced by sodium nitrate 2·5 gm.

No Potassium (–K).

As Cm. but potassium nitrate replaced by sodium nitrate 5·1 gm., and potassium phosphate by sodium phosphate 2·0 gm.

Quadruple Phosphate (4P).

As Cm. but in addition sodium phosphate 5·6 gm.

Low Phosphate (–P).

As Cm. but potassium phosphate replaced by potassium sulphate 1·0 gm.

There were forty-two trees in all, so that there were six trees in each series. Series –N received no nitrogen for the first two seasons, but as no new growth was being made a small amount of nitrogen (2 gm. potassium nitrate) was introduced into the stock solution.

Series 4P received no phosphorus for the first three seasons and later received 0·25 cm. di-potassium phosphate per litre of the stock solution.

Cultural Observations.

The following records were taken :

(*a*) Condition and colour of foliage.
(*b*) Length of new wood produced each year.
(*c*) Annual girth increase.
(*d*) Number and condition of fruits.
(*e*) Time of defoliation.
(*f*) Number of blossoms.

During the first year (1932) the trees made no new growth, possibly due to rather late planting, and to the fact that many large roots had to be cut at planting in order to fit the trees into the pots. The trees were not pruned at planting, but in the spring of 1933 the two-year-old branches were cut back about three-quarters of their length. This severe pruning gave rise to vigorous growth in most treatments. During 1933 one or two of the waxed corks which had given several years' service in a previous pot culture experiment, showed signs of decay. It was therefore decided to remove all these bungs and seal the holes with plaster of Paris. Unfortunately, whilst the initial set of the plaster of Paris was good, it proved most unsatisfactory when in contact with the moist soil after the pots were plunged. In consequence there was considerable rooting of the trees through the drainage holes in the early part of 1934. As soon as this was noticed the pots were lifted, the holes sealed with ordinary cement, but owing to this rooting the trees remained very variable throughout the remainder of the experiment. In consequence the following notes are based on 1933 records.

Series Cm (*Complete Nutrient Solution*).

Foliage was healthy, but a few lower leaves showed signs of yellowing during August. Growth was good, and there was a satisfactory increase in girth measurement of the trunk. Numerous blossoms were produced, but only a few fruits set on three trees ; they were, however, quite normal.

Series 2N (*Double quantity of Nitrogen*).

The leaves of trees in this series remained dark green in colour throughout the growing season. Growth was very vigorous, and the trees showed the greatest increment in girth of any series. Fruit bud production was good, but of the few fruits that set all were malformed and shrivelled due to faulty stoning.

Series –N (*Low Nitrogen*).

Foliage was small and pale green during spring and summer but about 10th August bronzing appeared, and the leaves finally turned red in October. Extension growth was poor and there was only a small increase in the girth of stem. A moderate number of blossoms were produced in 1933, but practically none in 1934 ; there was, however, an increase in 1935 probably due to the introduction of the small quantity of nitrogen into the nutrient solution during 1934. In 1933 there was a rather better set of fruit than in the other series.

Series $\frac{1}{2}K$ (*Half quantity of Potassium*).

Foliage was similar to that of Series Cm. Growth and girth increment were good. Blossoming was plentiful but only a few fruits set on two trees ; these were, however, quite normal.

Series –K (*No Potassium*).

The foliage was quite healthy in appearance until August when scorching occurred on older leaves. Shoot growth and girth increment were good. Blossom was plentiful and there was only a small set of fruit on three trees. The fruit was quite normal.

Series 4P (Quadruple quantity of Phosphorus).

Foliage was healthy, but the leaves appeared rather paler than those on trees in Series Cm and 2N. A few lower leaves turned yellow during August. New growth and girth increment were good. Blossom was plentiful but the set of fruit was almost negligible.

Series –P (Low Phosphorus).

Bronzing of the leaves occurred towards the end of May, and the young wood was dull red in colour. By 7th July this coloration of leaves and shoots had disappeared. Trees in this series were defoliated nearly three weeks before those in the other series. Growth was poor, but it was nearly three times as great as in Series –N (Low Nitrogen). Girth increment was only moderate. There was plenty of blossom in 1933 and there was a small set of fruit (better than in any series except –N) which ripened early and was small and dark red in colour. There was practically no blossom in 1934 and only a very small amount in 1935.

The foliage and growth characters obtained in this experiment are very similar to those obtained with comparable treatments in pot culture experiments with other fruit trees (2, 3, 4, 5, 6) and with hops (1). The following table gives the average total shoot growth, girth increment, and blossom buds in 1933.

Series.	Treatment.	Average total length of shoot growth.	Average No. of shoots per tree.	Average girth increment at 1 ft. from union.	Average number of blossom buds.	Remarks.
		cm.		cm.		
Cm.	Complete Nutrient Solution.	753	23	8·5	72	Healthy, apart from some yellowing of lower leaves in August.
2N.	Double Nitrogen.	819	22	12·3	74	Leaves dark green.
–N	Low Nitrogen.	137	12	3·4	47	Leaves at first pale and then bronzed and finally red.
½K.	Half Potassium.	637	19	9·0	61	Foliage similar to Cm.
–K.	No Potassium.	713	24	8·3	79	Scorching on lower leaves in August.
4P.	Quadruple Phosphorus.	751	22	9·0	59	Foliage rather paler than Cm. and 2N., but large and healthy.
–P.	Low Phosphorus.	363	16	6·0	51	Bronzing of leaves and red bark of young shoots in early part of season. Early defoliation.

Inoculation Experiments.

During the summer of 1933 the foliage of the trees was sprayed with a suspension of the bacterial growth of *Pseudomonas mors-prunorum*, with the object of inducing the leaf-spot phase of the disease, but owing to the dryness of the season no leaf-spot appeared.

As the summer of 1934 was also a dry one, leaf infection was not attempted that year. In the absence of leaf-spot it was unlikely that stem infection would take place in the autumn, when, as shown experimentally, the organism invades the stem, and in fact bacterial canker was quite absent up to the time the trees were inoculated, in the autumn of 1934.

On 26th October of that year each tree was inoculated in the stem with *Ps. mors-prunorum*. A culture of the organism was prepared on nutrient agar containing 5 per cent. saccharose. When the culture was 28 hours old the bacterial growth was transferred to a small flask of sterile distilled water to form a cloudy suspension. Each tree was inoculated at two places, on opposite sides of the stem, one about six inches below the crotch, the other at about fifteen inches above the surface of the sand. The inoculations were carried out by making a Λ-shaped cut through the bark, turning back the tongue of bark and inserting a drop of the bacterial suspension.

When the trees resumed growth in the spring of 1935 the cankers became evident ; by July they were mostly very clearly defined and it was possible to measure them. During July the trees were examined for leaf-spot, and bacterial spots resembling those caused by *Ps. mors-prunorum* were found on four trees receiving "No Nitrogen" and on three of the "Low Phosphorus" series, but not on the rest. It was most pronounced on two trees of the "Low Nitrogen" series which were the smallest trees in the experiment.

Towards the end of the month eight trees showed symptoms indicating that cankers had girdled the stems ; five bore yellowish curled leaves, on two the foliage was wilting, and one was defoliated. On each of the two trees with wilting foliage the upper and the lower canker had met so that nearly the whole of the stem from crotch to ground level was affected.

The cankers were measured to the nearest centimetre and the following figures obtained. The upper figure in each pair denotes the length of the upper canker, the lower figure the lower canker.

	Length of cankers in cm.						Average.	Average length of the twelve cankers.
Complete ..	14	31†	16	37†	15	37†	25	**33**
	3*	35	51†	64†	18	75†	41	
2N. ..	5	6	6	2	5	6	5	**17**
	26	49	5	24	44	27	29	
−N. ..	26†	23	12	2	6	45†	19	**20**
	17	19	7*	29	10	39†	20	
½K. ..	6	2	3	3	2	46	10	**14**
	15	7	12	6	8	62	18	
−K. ..	2	4	2	11	3	20	7	**17**
	20	29	24	32	20	36	27	
4P. ..	45†	31	18	17	41	40†	32	**38**
	68†	44	59	40	7*	51†	45	
−P. ..	2	3	2	0	2	2	2	**3**
	6	4	10	1	4	2	4	

* These low figures for the lower cankers are probably exceptional.

† These cankers completely girdled the stems.

The trees were examined again towards the end of the year. The cankers had not extended farther and, where they had not girdled the stems, callus had developed at the margins of the cankers. This agrees with former observations, on trees naturally infected and on inoculated trees, which showed that the cankers do not increase in size after their outlines become evident as the trees resume growth in spring.

On six trees both cankers had girdled the stem ; on two others the lower canker, and on one the upper canker only had girdled the stem. All these trees were dead above the cankers ; they comprised four in the " Complete " series, two in the 4P, two in the –N, and one in the $\frac{1}{2}$K series.

It will be noticed that on certain trees cankers from 40 to 59 cm. in length developed without girdling the stems. This again conforms with observations on naturally infected trees where sometimes long cankers develop without girdling the stems and consequently without killing the trees.

Discussion of Results.

In general the upper canker was shorter than the lower one. On certain trees the figure for the lower canker (marked with an asterisk) is much less than that for the upper ; this seems to indicate that for some unknown reason the lower canker was arrested in development and that the figure is exceptional.

The figures for the " Low Phosphate " series are consistently low and it would seem certain that the treatment had a pronounced effect in reducing susceptibility to canker.

With the exception of one lower canker the trees receiving " Quadruple Phosphate " were very severely cankered and the same applies to those receiving " Complete " nutrients, though on the whole the cankers of the latter series were not so extensive as those of the former.

On the trees of the rest of the series the average length of the cankers was approximately the same, but if one tree be excluded (with cankers of 46 and 62 cm.) the figure for the cankers of the " Half Potash " series was distinctly low.

As the " Complete Nutrient " is relatively high in potash, and since the trees of this series were badly cankered, it would seem that potash does not exert any restraining influence on the disease, and this is borne out by the series $\frac{1}{2}$K and –K where the average length of the cankers is much less than in the " Complete " series. Moreover in the series 2N where the proportion of N to K is increased the cankering is again reduced. This offers evidence in confirmation of results already recorded from a preliminary field trial (9).

Since the cankering was most severe in the " Quadruple Phosphate " and in the " Complete " series (the latter relatively high in potassium), it would seem that, until further information is available regarding the effect of potash and phosphate, it would be inadvisable to apply heavy dressings of potash or phosphatic manures in soil where Bacterial Canker of plums is prevalent. As the " Low Phosphate " treatment reduced the cankering almost to nil this is a further reason for avoiding excess of phosphate.

It seems probable, however, that the action of phosphate is an indirect one by reducing the availability of iron salts and this may be a factor that must be taken into consideration, as shown in the Appendix to this article by Mr. W. A. Roach.

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Summary.

The results are given of a sand culture experiment designed to test the effect of certain nutrients on the susceptibility of plum trees to Bacterial Canker.

The effect of the treatments on the general health and development of the trees is noted.

The trees were eventually inoculated with *Pseudomonas mors-prunorum* and the size of the resulting cankers recorded.

The largest cankers developed in the "Quadruple Phosphate" and the "Complete Nutrient" series, and the smallest in the "Low Phosphate" series.

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APPENDIX

By W. A. Roach

In Fig. 1 the treatments are arranged according to the average rate of growth of canker. It will be seen that excess of phosphate induced the most vigorous growth of canker, whereas there was least canker on the trees growing in the solutions deficient in phosphate. Excess phosphate is known to tend to interfere with the normal absorption of iron by the plant, especially when this is supplied in inorganic form, as in these culture solutions (1). Any interference in iron absorption should show itself in pale green or yellow-green foliage. The notes bearing on leaf colour were therefore collected and incorporated in Fig. 1. Three sets of trees (4P, Cm, –N) have yellow or pale green foliage. Nitrogen deficiency is a sufficient explanation of the pale green colour of the

leaves of the trees in the – N solution. We are left with solutions 4P and Cm which had sufficient nitrogen; the yellowness of the foliage of the trees growing in these two solutions may therefore have been due to an interference with the proper absorption of iron. Since the iron was supplied to the culture solutions in inorganic form it should give an intense red colour with a thiocyanate if it remained in a form readily available to the plant. Since the culture solutions were usually made up over night and added to the pots in the morning one set was made up over night and tested in the morning. A standard volume of saturated ammonium thiocyanate solution was added to a standard volume of each culture solution. The – P solution gave a faint pink colour, the remainder gave no colour. The – P solution, which was the only one inducing practically no growth of canker, therefore was the only one to give any indication of readily available iron twelve hours after being made up.

A set of solutions made up some weeks previously was also tested; even the – P solution gave no colour.

The tendency of the culture-solutions to render the iron "unavailable" was studied further by adding a standard volume of ferric chloride solution to each of the previously made mixtures of a standard volume of culture solution and a standard volume of ammonium thiocyanate solution. The solutions are arranged in Fig. 1 in order of the intensity of the colour produced. It will be seen that the order of the stale solutions arranged in this way is identical with that obtained by arranging them according to the growth of canker which they induce and that of the twelve hours old solution is practically the same. The 4P solutions gave a transitory pink colour which disappeared in a second or so. There was comparatively little colour

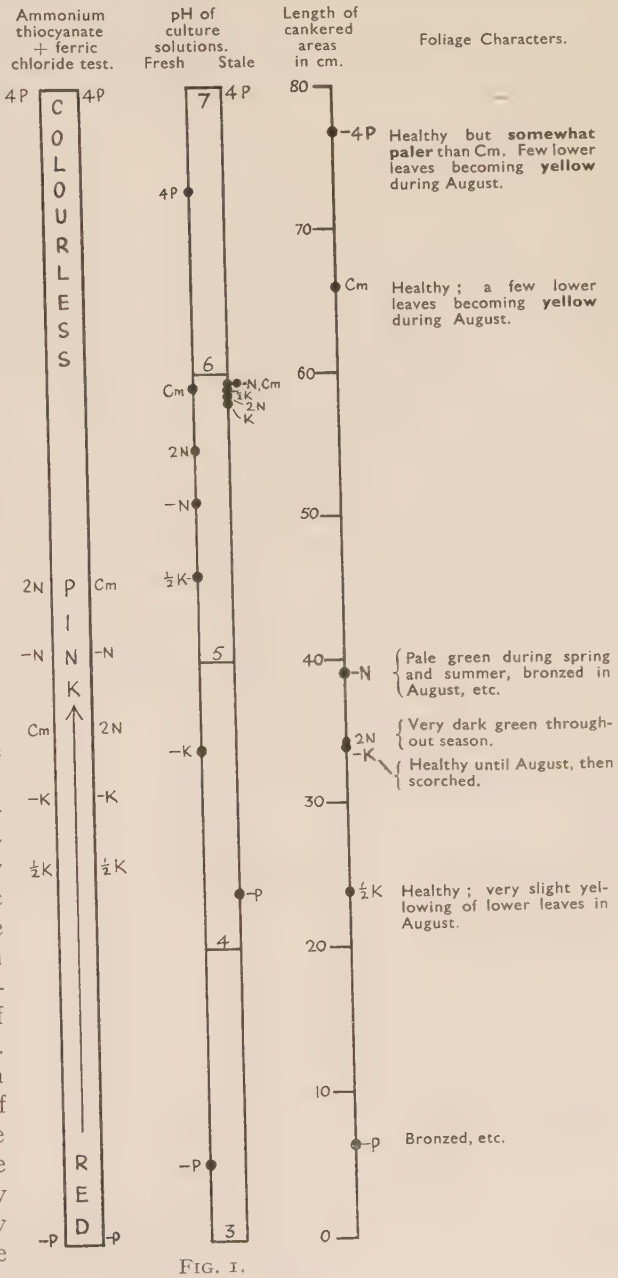

FIG. 1.

For description see text.

difference between solutions Cm, −N, 2N, −K and ½K, but the −P ones were markedly darker in colour. The intensity of colour is indicated roughly by the position occupied by the solution letter in the diagram.

The suggestion that iron was rendered difficultly available or unavailable in these solutions was confirmed by the fact that a precipitate formed in all the solutions after an addition of ferric chloride—immediately in 4P, in a few minutes in Cm, −N, 2N, −K, ½K and after some hours in −P, i.e. in practically the same order as that of decreasing growth of canker.

This precipitate must have been of ferric phosphate, formed according to the following equation :

$$K_2HPO_4 + FeCl_3 = 2KCl + FePO_4 + HCl.$$

In this chemical reaction acid is produced and the amount of this acid will vary from solution to solution according to the degree of precipitation of the iron. Dr. Hulme of the Ditton Laboratory very kindly determined the pH of the various solutions. The results are shown in the figure. The solutions again come in much the same order as that obtained by arranging them according to the growth of canker induced by them. The extremely low pH (high acidity) of the −P solution may well be the explanation of the poor growth of the trees in that solution.

Olsen (1) has shown that actual chlorosis tends to occur if there is insufficient organic matter, when the pH is between 6 and 7 ; the 4P solution is definitely in this dangerous region of pH and the Cm solution is just in it ; the 4P solution also has an excess of phosphate which enhances the chlorosis effect. These facts, therefore, explain the foliage characters of the trees growing in these two solutions.

The degree of resistance to canker, therefore, is sufficiently closely parallel to both the acidity of the culture solution and to the " availability " of the iron to raise the question as to whether resistance to canker may not be dependent on either a highly acid growth medium or one rich in iron or to a combination of both. The present results do not enable a distinction to be made between the possible effects of acidity and of available iron. Further experiments are, therefore, being started to study the effects on resistance to canker of acidity and available iron separately. The degree of acidity (pH = 4) which, in these experiments was associated with a sufficient degree of resistance to canker to be of practical importance, is beyond what can be contemplated in the field ; but a considerable increase in amount of available iron in the soil might well be brought about commercially.

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NOTES ON THE SILVER LEAF DISEASE

By H. WORMALD

1. Infection of Young Plum Trees.

The rapidity with which the Silver Leaf Fungus, *Stereum purpureum*, may invade and kill young plum trees was clearly shown in an experiment carried out on this Station during 1934-5. In connection with certain laboratory experiments it was necessary to obtain pure cultures of *Stereum purpureum*, so that these could be used in testing the toxicity of various substances towards the fungus. Cultures, apparently pure, were obtained without difficulty from the discoloured wood of trees showing Silver Leaf and also from particles of the tissues of the fungal fructifications. Later, spores were collected on sterile slides, over which the fungal fructifications were suspended, and using these spores, poured plates were prepared; the resulting "sporelings" produced cultures similar to those obtained from the infected wood and from the fungal tissues. It seemed certain therefore that all these cultures were *Stereum purpureum*, but as this fungus does not produce normal fructifications under artificial cultural conditions in the laboratory its identity could not be determined with certainty from these pure cultures. The most certain test for identification was to inoculate plum trees with the cultures and if this produced the typical Silver Leaf symptoms, followed by the appearance of the fungal fructifications on the infected trees, it would be proof that the fungus used for the inoculations was really *Stereum purpureum*.

On 21st November, 1934, using two cultures obtained from spores, four maiden plum trees (Victoria on Myrobolan B) were inoculated, two with one culture and two with the other. Each inoculation was carried out by making a Λ-shaped cut through the bark at a point about half-way along the stem, turning back the bark, and inserting a little of the fungal mycelium from an agar plate culture. Four other trees, as controls, were cut in a similar way but sterile agar only was inserted in the wounds.

During the summer of 1935 the trees inoculated with the fungus showed "silvered" foliage, while the leaves of the control trees were of a normal green colour. In September fructifications of *Stereum purpureum* appeared on the infected trees. There was thus no doubt that the fungus used in the inoculations was indeed *Stereum purpureum*, and the main purpose of the experiment had been achieved.

The condition of the trees indicated that the fungus had in each case extended throughout the stem and into the rootstock and, in order to obtain confirmation of this, the trees were pulled up for a more detailed examination. The following notes were taken on 4th October, 1935, about ten and a half months after the trees had been inoculated with the fungus. Trees 1a and 1b had been inoculated with one culture, 2a and 2b with the other.

1a (inoculated at 2 ft. 9 in. above ground-level). Quite dead; numerous fructifications from ground-level to 18 in. upwards (and also on some of the "feathers") including 4 inches of the stock.

1b (smaller tree, inoculated at 1 ft. 6 in. above ground). Quite dead; discoloration of the wood not only of the scion but also of the rootstock and of

a root at 2 feet from point of inoculation : many fructifications from ground-level to 1 foot upwards.

2a (inoculated at 2 ft. 9 in. above ground). Scion dead ; a living shoot on the rootstock ; rootstock discoloured and bearing fructifications but no fructifications on the scion.

2b (inoculated at 2 ft. 9 in. above ground). Two shoots still alive on lower end of scion, although the tissues of the stem were discoloured ; fructifications from ground-level to 1 foot upward ; discoloration of wood extending throughout the scion and rootstock and into the roots on the stock. On one root the wood was found to be discoloured at 6 inches from its point of origin on the stock—a distance of 3 ft. 9 in. from the point of inoculation.

On each tree the fungal fructifications were largest immediately above ground-level and they decreased in size upwards, the upper half of the stem at this time bearing no fructifications ; that portion of the rootstock below ground-level was also devoid of fungal fructifications.

Traces of mycelium were found in the discoloured wood of the infected root of tree 2b, and in order to determine whether this mycelium was that of *Stereum purpureum* the root was cut off and cleansed on the outside by wiping with cotton wool moistened with alcohol. The outer layers (cortex) were cut away and particles of the discoloured wood were removed at one inch and at four inches from the point of origin of the root ; these particles of wood were transferred to culture plates, and all gave rise to cultures similar to those obtained from spores of *Stereum purpureum*. It was evident therefore that in this tree the fungus had extended from the point of inoculation down the wood of the scion into the rootstock and roots, a distance of over three feet, during a period of about ten and a half months.

This experiment was not intended to prove the parasitism of *Stereum purpureum* for the work of F. T. Brooks and his collaborators at Cambridge has clearly established that the fungus is a direct cause of Silver Leaf, but it does offer confirmation of that work. This is perhaps worthy of mention for recently a Russian investigator* has maintained that the fungus is not the primary cause of the disease, but that Silver Leaf is brought about by adverse meteorological conditions, particularly low temperatures, and that the fungus appears merely as a saprophyte on the dead tissues ; he states, " *Stereum purpureum*, which has no bearing whatever on the manifestation of Silver Leaf disease, evolves solely on dead wood, chiefly in old orchards, and generally in such ones as have suffered from low temperatures, and cannot be placed either among the compulsory or the optional parasites."

In the experiment described in the present article the inoculated and the control trees were on similar rootstocks ; they were of the same age and were growing side by side in the same nursery row. That the appearance of Silver Leaf in this experiment was due to low temperatures cannot be the explanation, for the trees were all exposed to the same meteorological conditions, yet the control trees remained completely healthy while those inoculated with *Stereum purpureum* showed silvering of the foliage, and died within eleven months after infection.

It is to be noted that Brooks does not claim that *Stereum purpureum* is the only cause of foliage silvering, but his experiments demonstrate that infection with that fungus does result in Silver Leaf on certain host plants.

* Borggardt, A. I. " Silver Leaf of Fruit Trees. Its Cause and Prophylactic Measures of Control," Bull. Sci. Res. Inst. Southern Fruit and Berry Culture, Part 20, 7-30 (Russian with English summary). 1934.

FIG. 1.

Stem of double-worked pear tree showing the Silver Leaf fungus, *Stereum purpureum* on the "intermediate".

FIG. 2.

Upper part of the "intermediate" showing a "papery bark" canker.

2. A Stem Canker on a Double-worked Pear Tree.

A comparable instance of rapid invasion by the Silver Leaf fungus was shown in a young pear tree naturally infected, taken from a nursery row on this Station about the middle of October, 1935. The tree was quite dead and bore fructifications of *Stereum purpureum*.

The tree had been double-worked. The rootstock, Quince C, had been budded with Beurre Hardy in August, 1933. After the bud had grown out the stock was cut back in August, 1934. During 1934 the Beurre Hardy stem made good growth and in April, 1935, it was cut back and grafted at two feet above ground-level with Williams's Bon Chrétien. During 1935 the three buds of the Williams's graft-wood grew out and produced three strong shoots, the longest being 2 ft. 6 in. in length.

When the tree was examined in October there was a cankered area with " papery bark " extending from the upper union for about nine inches down one side of the stem (the Beurre Hardy intermediate). The lower half of the intermediate bore numerous small fructifications of *Stereum purpureum*, the largest being 1 cm. long, though they were mostly only 5 mm. or less.

The wood of the quince rootstock was discoloured and apparently invaded by the fungus. In order to ascertain whether *Stereum purpureum* was actually in the rootstock, particles of the wood were removed (after sterilizing the surface of the bark) at about three inches below the union and transferred to culture plates. These gave rise to cultures typical of *Stereum purpureum*.

It would seem, therefore, that infection had started at the upper union, probably at the time of grafting, and had extended throughout the " intermediate " stem and into the rootstock since the grafting in April, a period of about six months.

The association of the Silver Leaf fungus with a cankering of the stem and the peeling away of the outer layers of the bark in a thin strip is of interest in relation to a disease of apple trees that has been prevalent in certain plantations of top-worked apple trees. It is suspected that this " papery bark " disease of apple trees is also caused by *Stereum purpureum*.

Summary.

1. The rapid infection and death of young plum trees after inoculation with *Stereum purpureum*, the Silver Leaf fungus, is described. The fungus extended throughout the stem, and into the rootstock and roots.

2. A stem canker with " papery bark " was observed on a young double-worked pear tree infected with *Stereum purpureum*.

THE VERTICILLIUM WILT OF HOPS
SOME FACTS AND RECOMMENDATIONS*

By R. V. HARRIS

I. Introduction—Historical.

This disease was first identified in 1924 in a garden of the *Fuggle* variety, and also, less seriously, in a neighbouring garden of *Tolhurst* at Penshurst in Kent. No further cases were met until the 1930 season when additional outbreaks were examined in Fuggle gardens at Marden, Kent, and in a single garden near Hereford.† Finally, during the past three seasons of 1933, 1934, and 1935, four further cases in Kent and Sussex have been identified, all on Fuggles, two each in the neighbourhoods of Paddock Wood and Lamberhurst, respectively. Up to the present time, therefore, seven serious centres of attack have been reported, six in Kent and Sussex, one in Hereford.

II. Symptoms.

A varying proportion of the bines of affected hills wilt and die during the growing season. Where this takes place before picking, a corresponding reduction in crop takes place. The complete hill with its roots may be killed as a result of attack, but more commonly, the infected hill survives from year to year and only a varying proportion of its bines prematurely die. Affected bines are abnormally thickened and particularly swollen in the basal region but their bark only loses its normal green or brown colour at a late stage in the wilting process. Such bines, on being pulled, readily become severed from the crown and usually a portion of the crown tissues becomes detached with the bine. Infected bines do not " grow off " above soil level as is the case with Hop Canker. On cutting or otherwise severing a bine showing any but the extremely incipient symptoms of wilt, the wood cylinder is invariably found to be uniformly discoloured (a light brown colour). When the bines start to wilt early in the season (June or July) the leaves usually become rapidly and uniformly yellowed and then blackened, commencing with the leaves at the base. In later instances the initial symptom is usually an interveinal yellowing and withering of the lower leaves extending upwards and culminating in the wilting and browning of the cones. In severe cases, all the bines of a hill may be completely wilted or blackened and dead before picking, but most commonly, only a proportion of the bines are thus early affected.

III. The Causal Fungus.

(*a*) *Isolation and Identification.*

Fungal hyphae were invariably found in the discoloured wood cylinder at the base of wilting bines. A fungus isolated with great regularity from this region was identified in artificial culture as *Verticillium albo-atrum* Rke and Berth. This fungus and related

* Paper read at a Conference on Hop Growing held at the South-Eastern Agricultural College, Wye, on 15th January, 1936.

† The writer is indebted to Mr. L. Ogilvie, Advisory Mycologist at the Long Ashton Research Station, Bristol, for calling his attention to this outbreak and for facilitating its investigation.

species are known to be the cause of wilt diseases of many other crops, such as potato, raspberry, tomato, etc.

(*b*) *Inoculation Experiments.*

A series of experiments commenced in 1925 proved conclusively that this fungus (*Verticillium albo-atrum* Rke and Berth.) is the primary cause of the disease. In the 1925 and 1926 experiments the inoculations were made on new sets previously potted up in ordinary soil, not rich in nutrients. The growth of the bine was poor and the results of the inoculations inconclusive. In 1927 and 1928 one-year-rooted sets were potted up in rich soil taken from the hop gardens at Penshurst and at East Malling, and similar sets potted in a specially mixed greenhouse compost rich in nutrients were also used. In both these years a much more vigorous growth of bine was obtained and the inoculations were followed by a striking development of all the characteristic symptoms on the inoculated plants. It would appear from these experiments that the degree of parasitism of bines by the fungus is greater under conditions inducing a vigorous and succulent bine growth.

(*c*) *The Distribution of the Causal Fungus in an Infected Hill.*

The causal fungus has been identified in the wood of the roots, and of the main underground stem system, and in the wood and pith of the bines from below ground level upwards for a distance depending on the stage of parasitism of the bine reached at the time of the examination. The spore-producing organs of the fungus have never been observed on the aerial parts of hills under field conditions and the bines become normally infected by the passage of the fungus into them from the rootstock through the water-conducting wood vessels. There is therefore good reason to assume that primary infection takes place from the soil and that the main seat of the fungus thenceforward is the underground part of the hill. This is confirmed by the fact that when badly wilted hills have been grubbed and the gap replanted with sets taken from symptomless gardens out of the affected neighbourhood, these sets have invariably developed symptoms of wilt the following year.

IV. The Incidence of the Disease.

Extensive individual-hill records on the incidence and intensity of the disease are now available over a period of some ten consecutive seasons at Penshurst and these, together with similar and subsequent records on the other affected gardens, show :

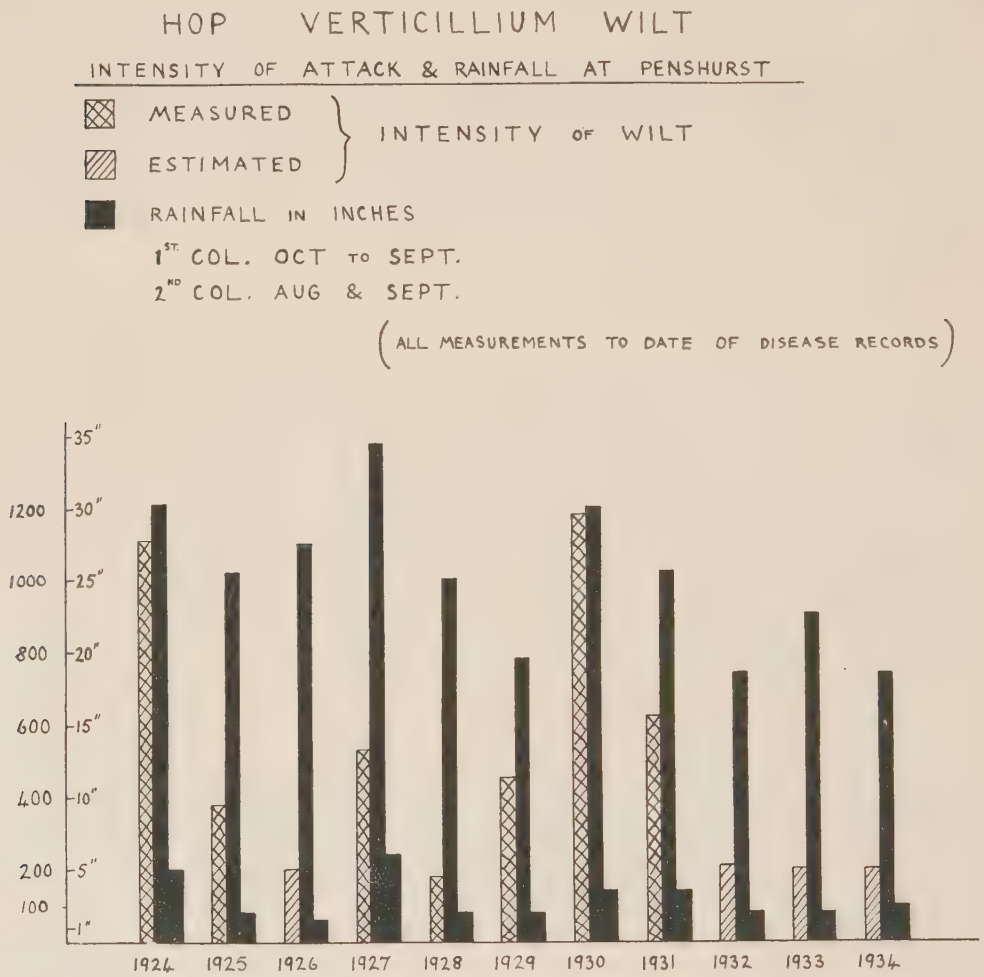
(1) that the disease-fungus is distributed throughout the great majority of the hills in these gardens irrespective of the wilting of bines before picking ;

(2) that the intensity of attack in terms of such bine wilting (as distinct from incipient and hardly detectable leaf symptoms) is primarily related to fluctuations and variations in the environmental conditions (seasonal and soil) under which a particular hill is growing.

(*a*) *In Relation to Seasonal Fluctuation.*

Records made at Penshurst show clearly that disease symptoms do not necessarily become progressively more severe from year to year ; in fact, the reverse is often the case. Thus a hill showing severe symptoms one year may, if it is not actually killed, be free from dead and wilting bines the following year. The accompanying diagram

shows clearly the correlation of disease intensity with rainfall. Generally speaking, a wet season is accompanied by severe wilt and vice versa. During the past four years the disease at Penshurst has been so slight in intensity as to be almost negligible, and that following very severe attacks throughout the same garden in 1924 and 1930. It is likely that the effect of high rainfall in encouraging this disease is indirect in nature being probably bound up with temperature, i.e. it is clear that a complex of environmental factors is involved, one of which is rainfall.



(*b*) *In Relation to Soil Variation.*

The records of wilt intensity from hill to hill throughout a garden in any one season were further found to show a striking relationship between the situation of severely affected hills and the conformation of the soil. Affected gardens fall into two categories according to the mode of distribution of severely wilted and completely killed hills. The first consists of gardens on a regular slope, and in such, severely affected hills appear in small scattered groups or singly throughout the garden. The second includes

gardens which are approximately level, and in all such cases the severely wilted stools are concentrated in one or more large irregularly shaped patches or zones, giving the appearance (purely illusorily) that infection has occurred at one or two spots and is spreading outwards into the rest of the garden. These correlations indicate a possible relation between severity of wilt and soil structure, and preliminary soil surveys of the affected gardens, in collaboration with Mr. Basil Furneaux, of the South-Eastern Agricultural College, Wye, were commenced in 1932. As far as these surveys have progressed, a remarkable parallelism has been found between the soil structures and textures in all the affected gardens in Kent and Sussex, and also a striking correlation between intensity of wilt attack and impedence in soil drainage, i.e. the soil in a zone of severe wilt attack has to date invariably shown evidence of soil conditions conducive to a slower disposal of water than in parts of the garden where the bines only develop incipient leaf symptoms of wilt before picking.

V. Control Measures.

(*a*) *Soil Treatments.*

In the early years of the investigation attempts were made to control the disease at Penshurst by soil dressings of lime in order, by checking acidity, to produce conditions unfavourable to the growth of the fungus in the soil. We are greatly indebted to Dr. Goodwin of Wye for undertaking the analyses on which this work was based. Dr. Goodwin also discovered deficiencies of potash and phosphates in the soil and dressings to remedy this deficiency were made with the object of controlling the disease by inducing a healthier growth of the bines. These experiments, however, yielded inconclusive results.

(*b*) *Grubbing Diseased Hills and the Use of Soil Sterilants.*

Such methods of control which aim at checking the spread of the fungus from wilting hills to normal hills are not likely to be effective, as recent data, described in the foregoing sections, indicate that although the wilting hills may be localized in a clearly defined patch or zone, the fungus is actually widely distributed over the affected garden, i.e. the distribution of actual bine-wilt bears no relation to the distribution of the causal fungus in all the affected gardens so far examined.

(*c*) *The Use of Resistant Varieties.*

Up to the present economic attacks of the disease have only been observed on the Fuggle variety. Recently, gardens of other varieties abutting on severely attacked zones of Fuggle have been examined and no trace of wilt has been detected although soil borings have revealed conditions usually associated with severe wilt in Fuggle. To test this apparent resistance further experiments are in progress in which other varieties of hop are being planted in the centre of severe Fuggle-wilt zones.

(*d*) *Soil Conditions.*

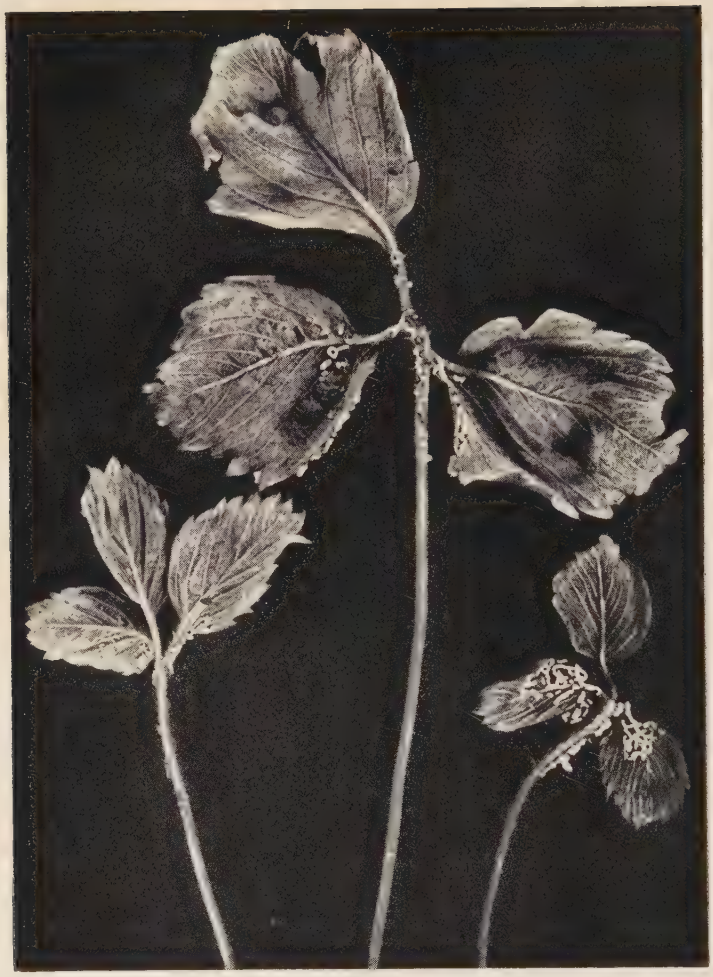
Finally the close apparent correlation of severe wilt with soils showing certain properties in relation to water disposal, indicates the possibility of control by drainage improvements calculated to bring the soil in the severe-wilt zones into line with that outside these zones. If this cannot be done we are up against a definite limitation in soils suitable for the growing of the Fuggle hop. It may thus be found advisable to avoid

certain types of soil not because they will not grow Fuggle but because they will induce severe wilt under certain seasonal conditions.

A programme of continued investigations of the soils in affected gardens in collaboration with Mr. Furneaux is being drawn up with the object of ultimately being able to determine accurately by a series of borings, the wilt potentialities of a given soil before planting.

Summary.

A brief outline of the progress of the investigation of this disease to date is given with reference to its symptoms, cause, incidence and control.



A Slime-fungus *Physarum cinereum* found on Strawberry Leaves.

(Block loaned by *The Gardeners' Chronicle*.)

A SLIME-FUNGUS FOUND ON STRAWBERRY LEAVES*

By H. WORMALD

About the middle of September Dr. A. M. Massee drew my attention to a conspicuous fungoid growth infesting the petioles and leaflets on a Royal Sovereign strawberry plant which was one of a batch that he was cultivating for experimental purposes in a greenhouse at this Station. The leaves though somewhat distorted showed no definite lesions, but on one leaf, on each of the two lower leaflets, there was a dark discoloration on the upper surface near the stalk end, the discoloration corresponding to an abundant development of the fungal growth on the lower surface.

This fungus-like growth was mostly on the lower surface of the leaves but on some leaflets it had extended round the margin to the upper surface. It consisted of white, pear-shaped or peg-like outgrowths and of elongated, wavy or branched ridges, forming in places a kind of network projecting about 1 mm. from the leaf surface.

On teasing a little of this out in water and examining it microscopically it was found to consist of a thin white membrane containing numerous dark-coloured spherical spores provided with minute warts. This structure together with the fact that the organism was producing little or no damage to the leaves suggested that the outgrowths were the fructifications of a Slime-Fungus or Myxomycete, and on submitting a specimen to Miss E. M. Wakefield at the Herbarium, Kew Gardens, it was found to be *Physarum cinereum* Pers.

Some of the lower forms of the Myxomycetes are known to be definite parasites, for example, *Plasmodiophora Brassicae*, the cause of Club Root (or Finger-and-Toe) in turnips and cabbages. The higher forms are saprophytic, living on dead organic substances, although sometimes they may invest living plants so densely as to check growth. One well-known Myxomycete, *Spumaria alba*, in this way forms large, foam-like masses on the stalks and leaves of grasses.

It would seem then that in its plasmodium (or slime) phase *Physarum cinereum* had been living on the debris of the old decaying strawberry leaves and that this plasmodium had finally crept up towards the light, along the leaf-stalks of the younger, living leaves in order to produce its sporangial fructifications. As will be seen from the photograph these fructifications are mostly in the region round the point where the leaflets are attached to the petioles. This is explained by assuming that the plasmodium, creeping up the petioles, divided up on reaching the lamina, a portion passing to each of the three leaflets.

Such an infestation by a saprophytic myxomycete is not likely to lead to serious consequences and can readily be checked by taking out the leaves bearing the fungus. In the present case the conditions under which the plant was growing (the moist warm atmosphere of the greenhouse) must have been particularly favourable for the development of the fungus, especially as the plant was in a small pot and bore numerous crowded leaves. The affected leaves were removed and the slime-fungus has not been seen again on that or other plants of the same batch.

* Reprinted from *The Gardeners' Chronicle*, Vol. 98, p. 339, 9th November, 1935, by permission of the Editor.

ENTOMOLOGY

NOTES ON SOME INTERESTING MITES AND INSECTS OBSERVED ON HOPS AND FRUIT TREES IN 1935

By A. M. MASSEE

1. The Hop Red Spider (*Tetranychus telarius* L.).

Although the Hop Red Spider does not occur in all hop gardens, a fact which may well be accounted for by varietal resistance, it is pretty widely spread throughout Kent, and during the year it has been very persistent at Cuxton (as in many years past), West Farleigh, Marden, Goudhurst and Tonbridge.

It has now been definitely established that the Hop Red Spider commences to infest the bines, and feed on the tender growths in the early spring. This year the initial infestation was observed to commence during the latter part of April. In the past several methods of control have been advocated, the foremost being the liver of sulphur spray which is applied during the summer months. Other sprays such as flour paste, derris, nicotine, and dusts including flowers of sulphur and nicotine have been tried with only partial success.

The advice given to growers in the past has been to spray the hops during the latter part of July and in August with a liver of sulphur spray. This information proved to be of some value since if the spraying was done efficiently the mite was kept in check, but it was never eradicated entirely, and it is probable that if the spraying was carried out diligently more good would be done by breaking the web made by the mites than by actually killing the acari.

Now that more is known about the life-cycle and habits of the mite, control measures have been revised and modified considerably. For example, since the red spider begins to infest the bines as soon as they commence to make growth, the spraying programme has been brought forward accordingly, and now the spraying is carried out before the red spiders establish themselves, and probably, what is the more important, before they make their silken webbing under which they seek shelter and reproduce.

An experiment carried out in a hop garden at Cuxton proved to be of more than passing interest. During the last week of April, the adult female red spiders came out of their hibernating quarters, such as cracks in the poles and from the soil, and literally swarmed in thousands on the tender bines. At this period the hops were "pulled" and all surplus material was carefully collected and burned. Thus very little bine was left to spray. It was decided to spray with a proprietary pyrethrum spray. This was used at a strength of 2 per cent., together with 5 oz. of a sulphonated lorol wetting preparation. The spraying commenced on 1st May and was completed by 6th May, care being taken to apply the wash on warm days when the spiders were more in evidence. The spray was applied by means of knapsack sprayers and, in addition to spraying the bines, the poles were also sprayed up to a height of eight feet, since a few spiders were still sheltering in the cracks of the poles.

The effect of this one application of Pyrethrum was indeed striking. The red spider was practically eradicated from the sprayed portions of the garden and these remained free throughout the season. Red spiders could be found everywhere on the unsprayed part, and they were noted to be very prevalent at picking time.

Although it will be agreed that only one experiment of this nature cannot be accepted as conclusive, it is clearly evident that a pyrethrum spray applied at the correct strength, and at the proper time, might prove to be the solution of the hop red spider problem as it was at Cuxton in 1935.

Finally it should be noted that it was a " pole-work " hop garden which had been badly infested every year to several years past, and the yield has been materially reduced in consequence.

2. The Oat Aphid (*Myzus festucae* Theo.).

The Oat Aphid has been exceptionally common in many parts of Kent and outstandingly so at Birling and in the Tonbridge districts.

This aphid feeds on several species of grasses in addition to the winter oat, and when the aphid is very common it may cause considerable damage to the crop. For example, a large acreage of winter oats growing at Birling had to be ploughed in on 27th May on account of the very poor growth, while a piece adjoining which was not ploughed in failed to produce a crop. The total acreage ploughed in throughout Kent must have been very considerable.

3. The Abundance of Aphides on Oats, Apples and Plums.

The abundance of aphides on oats has been referred to already, but mention must be made to the increase of these insects on fruit trees and bushes. Two species of Apple Aphides, namely the Rosy Apple Aphid (*Anuraphis roseus* Baker) and the Permanent Apple Aphid (*Aphis pomi* De Geer) have been very common in many plantations whether they were sprayed with a tar oil wash in the winter or not, and it has been more like old times to see these pests of ten years ago back with us again.

Two species of Plum Aphides, the Hop-Damson Aphid (*Phorodon humuli* Schr.) and the Mealy Plum Aphid (*Hyalopterus arundinis* Fabr.) proved to be more prevalent than usual and contact sprays had to be used against them in the spring months. The Leaf Curling Plum Aphid (*Anuraphis padi* L.) was also widespread in the Maidstone district.

It is difficult to explain why these aphides should prove to be so common since one would have expected the severe frost of 16th-17th May to have affected these fragile insects in the same way as it did many other species which infest fruit trees.

4. The Wood Leopard Moth (*Zeuzera pyrina* L.).

The larvae of this wood boring moth is enquired about regularly each season from various parts of Kent.

It is generally found on apple in this county, but frequently attacks the smaller limbs and branches of cherries, pears, plums, walnuts and other trees including the chestnut.

Specimens of the larvae were received from Pembury where they were found boring into the larger growths of black currants. The black currant appears to be a new host for this insect, but since it has a very wide range of host plants it is probable that it will feed on most trees should the necessity arise.

5. An Uncommon Case-Bearer on Apple.

Several species of Case-Bearers are recognized as being minor pests on fruit trees, but while on an advisory visit at Paddock Wood last June, an unknown species of Case-Bearer was noted on some apple trees. The larva of this species lives in a greenish-grey case which is three-sided and straight, and the case is nearly half an inch long. Some larvae which were reared in the laboratory by Mr. R. M. Greenslade were feeding on the bark of some apple twigs which were contained in a jar of sand and water. The normal hosts of this species are said to be lichen growing on fences and tree trunks.

The moths which hatched out some weeks later proved to be all females of a small wingless Tineid Moth, the species being *Solenobia inconspicuella* Staint. The female is inactive, and it has to be examined with a hand lens in order to determine that it is a small Tineid Moth.

6. The Red Plum Maggot (*Laspeyresia funebrana* Treits.).

Although the plum crop was very materially reduced owing to the frost, it was surprising to find so many outbreaks of the Red Plum Maggot in areas which escaped the frosts. It was plentiful in the Paddock Wood district, and in some instances consignments of fruit which were dispatched to the local cannery were condemned on account of this pest. It was also reported from Southfleet, and it seems to be rapidly establishing itself in this large plum area.

7. The Common Swift Moth Attacking Strawberries.

The Common Swift Moth (*Hepialus humuli* L.) has frequently been recorded attacking the roots of hops and strawberries, and it is usually found on the latter host when the hops are grubbed and strawberries are planted in their place immediately afterwards.

The Swift Moth has been recorded from Ryarsh and West Farleigh, but this year it has also been noted at Goudhurst in addition to the above localities. It is the larva of this moth which causes the trouble. It bores into the core of the roots, below ground level, and often hollows out the crown of the plant, causing it to wilt and finally die. The attack at Goudhurst was quite serious and at present there seems to be no way of checking this insect once it has become established in the soil.

This and many other root-feeding insects may cause considerable damage to newly planted strawberry fields, and as a precaution against them it would be well worth while to make a survey of the land before the strawberries are planted out.

8. An Homopterous Insect on Apple.

Ledra aurita L. is a very handsome Homopterous insect which normally feeds upon oak. It is considered to be a widely distributed species, but only locally common. Its headquarters appears to be the New Forest in Hampshire.

This season a number of nymphs were found feeding on apple leaves in a derelict orchard at East Malling. Incidentally the orchard adjoins a wood which contains oaks. Ledra has also been found on apple trees at the Research Station, and doubtless it is far more plentiful on this fruit than it is generally presumed to be. This insect is not a pest, but it is just one more example of an oak insect adapting itself to apple. Others include *Rhynchites coeruleus* DG. and *Tortrix viridana* L.

9. Some Anthocorids and Allied Bugs on Apple Trees.

A number of small rather insignificant plant bugs occur on fruit trees, and one of them, namely *Anthocoris nemorum* L., is known to be predaceous upon the Fruit Tree Red Spider. Some, if not all, of the other species are probably predaceous as well.

A number of species of these bugs were recorded from corrugated cardboard bands which were removed from the stems of apple trees in October. Among them may be noted *Anthocoris nemorum* L., *A. nemoralis* F., *Xylocoris ater* Duf., *A. gallarum-ulmi* De. G., *Lyctocoris campestris* F., *Triphleps minuta* L., *T. majuscula* Reut., *Taphropeltus contractus* H.S., *Scolopostethus decoratus* Hahn., *S. affinis* Schill. and *S. thompsoni* Reut.

Some species of Anthocorids occur very plentifully on fruit trees and they must play an important part in checking some of the more harmful pests present.

In addition to the eleven species referred to above, eight examples of another species, so far not identified, and possibly new to the British list, were found. These have been referred to the specialists on the group for their considered opinion about the species in question.

10. A Rare Aradid Bug on Apple.

Some twenty-four nymphs of the very rare aradid bug (*Aradus aterrimus* Fieb.) were found on trunks of apple trees and in corrugated cardboard bands on the stems of the trees in an orchard at East Malling last October. This very rare bug was first recorded in this country seventy years ago when two specimens were found in Kent. It appeared again at East Malling in the autumn of 1933. At that date some fifty specimens were collected.

The occurrence of nymphs taken this autumn in an apple orchard is rather mysterious. The species in this family of insects are considered to be fungus feeders, and they are generally found under bark of trees where fungus growths occur. The trees at East Malling, however, have received a winter wash regularly for several seasons now and there is no evidence of any fungus growth at all. A thorough search in the plantation has failed to find more of these black " Flat " bugs.

A number of species of Aradids have been recorded from Russia, and one species *Aradus cinnamomeus* Panz. is injurious as a primary pest to young pines (*P. silvestris* and *P. nigra*). It is said to attack trees from five to twenty years old. Another species, *Aradus aterrimus var. moestus* Reut. is also noted in Russia.

11. The Red Bud Borer (*Thomasiniana oculipeda* Rubs.).

The little red larva of this fly frequently causes severe damage to newly budded apple stocks, and it has been causing serious damage to some stocks in the nursery at the Research Station. This pest is more serious than many people realize and the damage it causes does not show up until it is too late to do anything against it. The larva works its way under the new buds, and causes them to fail to " take ".

If this pest is known to persist each year in any given place, it can be partly controlled by coating the buds thoroughly with a commercial petroleum jelly. The petroleum should be applied immediately after the tying of the buds.

12. The Pear and Cherry Slugworm (*Eriocampa limacina* Cameron).

The larva of this sawfly which is referred to as the Pear and Cherry Slugworm is sometimes very abundant on pear trees and occasionally on cherries. During the last two seasons it has been very prevalent on cherries in the Faversham and Sittingbourne districts.

It does not appear until the middle of the summer when all spraying operations are finished, and thus it is often overlooked and much damage and defoliation is done before it is detected.

Where this pest occurs a careful watch for its presence on the leaves should be made from the end of June onwards. The young larvae can be readily controlled by spraying with derris, nicotine, or lead arsenate. Dusts are also effective against this insect which fortunately is a very easy pest to exterminate.

13. The Stag-Beetle Attacking Cherries.

The Stag-Beetle (*Lucanus cervus* L.), one of our largest British Coleoptera, usually feeds in the larval stage in trunks and larger roots of elm trees. It does not appear to have been recorded feeding on cherry, and therefore it is of interest to note that it was found attacking the roots and stem of a cherry tree in the Rainham district. The tree was so badly damaged that it was necessary to grub it. While it was being grubbed a dozen or more large whitish larvae (2 to 3 inches long) were found living in the stem.

In the Wye Report for 1904 Theobald refers to this insect as occurring in the roots of Aspen but the fact that it may attack fruit trees is not mentioned.

14. The Osier Aphid (*Pterochlorus saligna* Gmelin).

The Osier Aphid has appeared on some willows which have recently been planted at East Malling for use as packing sticks, etc. This large dark brown aphid which often occurs in dense colonies on stems of willows and osiers is very conspicuous. The colonies are often a foot in length. Generally speaking this aphid is not of economic importance, but sometimes it occurs in such large numbers on ornamental willows that it destroys them.

It has been reported on apple in North Wales but it did not occur on the apple stocks at East Malling which were adjacent to the infested willows.

15. The Effect of the Severe Frost of 16th-17th May on some Fruit Pests.

Although it has not been possible to study the effect of the great frost of 16th-17th May on insect pests in detail, it is of interest to record a few observations.

Undoubtedly the most striking observation was made on the morning of 17th May, at 9.30 a.m. when an orchard of mixed varieties of plums was examined. This orchard has been infested by the Plum Sawfly (*Hoplocampa flava* L.) for a number of seasons, and the infestation was becoming more severe each year. In 1935 a large proportion of the plums of some varieties were " struck " by Sawfly larvae. The frost caused great havoc in the orchard and it was obvious that the whole crop had been lost. A majority of the small plums had already turned black and many of them were wet and sticky. The effect on the small larvae was curious. Some were still inside the fruitlets and appeared to be unharmed. Others were endeavouring to leave the fruits, but had died when half way out. Some of these were much darker in colour than usual and somewhat shrivelled. Quite a number were observed to fall to the ground. These were collected and placed in a tin containing damp sand and were kept in the laboratory. They all died the same day. Two days later a further examination of the orchard was made, and it was only possible to find odd larvae after a careful search, and the majority of them were dead and shrivelled.

It is safe to assume that the plum Sawfly was practically exterminated in this orchard, and it will be of very great interest to note whether it appears again in the same place next year. There is little doubt that the same phenomenon happened in many

other parts of Kent where this insect occurred, and it is quite possible that little will be heard of the Plum Sawfly again for several years. After all it has only been an economic species in commercial plantations during the past two or three seasons.

Another insect which has been partially upset by the frost is the Apple Sawfly (*Hoplocampa testudinia* Klug.). However, since the egg-laying period of this insect is later than that of the Plum Sawfly the effect has not been so severe. Adult sawflies were noted on the wing on Good Friday, the 19th April, and egg-laying was not completed until the 27th May.

In some districts, such as Marden, where the apple crop was wiped out almost completely, there is bound to be a marked effect on the sawfly population next season. In an orchard at East Malling containing standard Bramley trees the crop was confined to three trees which for some unknown reason withstood the frost. The total crop on these trees amounted to approximately two bushels. Every single fruit was infested with sawfly larvae ; as many as six were found in some of the fruits, and the majority contained more than one larva. Similar observations were made elsewhere. Thus it would appear that the adult sawflies which were still on the wing after the night of the frost concentrated on the few trees which were likely to bear fruit.

The local distribution of insects in an orchard varies according to seasonal weather conditions, and this point was very well illustrated in an apple plantation at East Malling. The orchard in question contained five acres of bush Bramleys, Lanes and Newtons, one half being planted with Lanes and Bramleys alternately, the other with Newtons and Lanes. The crop was very scattered, and more than half the trees bore no fruit at all.

The orchard was used for a corrugated cardboard banding experiment. The bands were removed in October and a complete inventory was made of the Apple Blossom Weevils and Codlin Moth larvae present in the bands of each tree. Now it was found that while the weevil population was about the same throughout the orchard (on trees with crop and those without), the Codlin Moth larvae invariably occurred on the trees with a crop only. The non-cropping trees produced no larvae. Thus it would seem that the Codlin larvae do not wander far away when seeking their winter quarters, while the weevils, on the other hand, tend to travel some distance before they finally settle down and hibernate. There is evidence to show that the weevils were concentrated on the trees with a crop earlier in the season, since the foliage of these trees was appreciably nibbled by the weevils, whereas the non-cropping trees showed very little signs of weevil damage caused by their feeding on the foliage.

The observations referred to above are of extreme interest, but the very full programme of a Research Entomologist does not allow sufficient time for adequate observations to be made on such a wide and varied subject.

16. Apple and Plum Shot-Hole Beetles.

The Shot-Hole Beetles which occur on fruit trees have been noted from time to time in various localities in Kent and Sussex, but this season the requests for information concerning these insects have been more numerous than usual. Severe outbreaks have occurred in the Swanley district, at Plaxtol, near Sevenoaks, and in West Sussex.

It is generally understood that this group of wood-boring beetles only attack trees which are growing in low-lying, waterlogged areas, and trees which are unhealthy for one reason or another.

This year's experiences, however, tend to show that the unhealthy tree theory is not the correct one. The attacked Bramley trees in West Sussex are as healthy as one could wish to see, and the general vigour and growth of the trees is far above the

average. Yet many of the trees are literally riddled by the borings of these beetles. The attack is not confined to the stems, since many of the stouter branches are affected also. Curiously enough some plums in the same orchard which are far from being healthy are not being attacked by these Scolytid Beetles. This is difficult to understand since the beetles usually prefer plums to apples. Four species of Scolytids are concerned with the outbreaks in West Sussex. They are *Anisandrus dispar* F., *Xyleborus saxeseni* Rz., *Scolytus pruni* Rz. *and S. rugulosus* Rz.

Anisandrus dispar F. is the principal species while *Scolytus pruni* Rz. is next in importance. The other two species are present in small numbers but they are by no means common. All four species have occurred at Swanley this summer on damson and plum trees, while *Anisandrus dispar* was reported on apples from Plaxtol.

As can well be imagined these wood boring beetles are very difficult to exterminate once they become established. If only a few trees are infested it well repays to grub them and thus remove the source of infection. If, however, the attack is widespread, this is impossible and other measures must be tried. Some material good can be obtained by spraying the trunks in April with a 10 per cent. tar wash, the idea being to kill the adult beetles just before they emerge from their galleries for their brief flight period. This method has been tried several times with marked success. It is difficult nevertheless to believe that all the beetles are destroyed by just one application of tar oil.

17. The Codlin Moth (*Cydia pomonella* L.).

These notes would not be complete this year without some reference being made to the Codlin Moth problem.

The Codlin Moth has been referred to in these notes for a number of years now, and the point has been stressed that if it keeps on increasing it will again become a serious pest as in bygone days.

The fact that Codlin Moth is universally common this year in England may be explained as follows. It is possible that the Codlin Moth has been steadily increasing during the past eight years or so and has now reached a peak when it has become a serious pest. Alternatively it may be that we are noticing Codlin Moth more this season because it is concentrated on the trees which are cropping and that it has left the non-fruiting areas severely alone. Whatever explanation proves to be the correct one, it must be borne in mind that Codlin Moth has not suddenly appeared without any reason. Last season, for example, Codlin was abundant everywhere but in the majority of instances it was overlooked. The huge crop was largely responsible. Most of the fruits which were infested with Codlin maggots fell to the ground, and since in a glut year there was little or no demand for " drops " the Codlin just remained unnoticed.

The population of hibernating Codlin Moth larvae on the trunks of some Bramley's Seedling trees at Southfleet in the winter of 1934-5 was tremendous. The larvae removed from under the loose bark of one tree amounted to over 500 and they took an hour to collect. This season the infestation proved to be so great that the bark of every tree trunk had to be scraped to remove the larvae, and allow birds, such as the Great Tit, to hunt for the remaining larvae.

It will be interesting to note the Codlin Moth problems again next season. Will it be a formidable pest, or will it practically die out as it did some ten years ago? It is quite possible that variable weather conditions account for the increase or decrease of this insect.

Summary.

Brief notes are given on a number of insects and a mite which are associated with fruit trees and bushes and hops, special attention being paid to those of economic importance.

STUDIES ON THE TRANSMISSION OF THE STRAWBERRY VIRUS "YELLOW-EDGE" DISEASE BY INSECTS*

II. APHID TRANSMISSION EXPERIMENTS AND PERIOD OF INFECTIBILITY

By A. M. MASSEE

Introduction.

In the field experiments of 1933-4 evidence was obtained that the strawberry virus "Yellow-edge" disease could be transmitted from diseased plants to healthy ones by the aphid, *Capitophorus fragaefolii* Cockll. It seemed desirable, however, to repeat the experiment in 1935, with some modifications, in order to obtain further information regarding the association of "Yellow-edge" and the aphid.

Experiments were designed therefore with a view to obtaining confirmation that the Delicate Strawberry Aphid is a vector of "Yellow-edge", to determine during which months of the year it is able to transmit the virus, and to obtain some information of the number of aphides required to produce typical virus symptoms on a healthy plant.

In addition further efforts have been made to ascertain whether the Strawberry Tarsonemid Mite, *Tarsonemus pallidus* Banks, is a vector of "Yellow-edge".

Experimental Material.

The experiment was conducted on exactly parallel lines to that of the 1933-4 investigations. Royal Sovereign plants were of the same clone as those used in the 1933-4 experiment, and were shown to be free from "Yellow-edge". These plants were raised in the summer of 1934 and were sprayed at weekly intervals. During October, 1934, 180 plants were selected as being as similar as possible in vigour and size. They were subjected to the warm water treatment which has now become a routine practice in the experimental strawberry work at East Malling. They were transplanted to seven-inch pots, and were plunged in the soil in rows of six bays, each bay consisting of thirty plants.

The investigation was carried out on the same site as the previous experiment.

Treatment of Plants.

Since the plants were growing under natural conditions (and were not confined in cages or muslin bags) special precautions had to be adopted to minimize the risk of

* The first article of this series, entitled "On the Transmission of the Strawberry Virus 'Yellow-edge' Disease by the Strawberry Aphis," together with "Notes on the Strawberry Tarsonemid Mite" was published in the *Journ. Pom. and Hort. Sci.*, 1935, **13**, 39-53.

stray insects and mites infesting them. As a result of the warm water treatment the plants were free of insects and mites to commence with. During the first week of March, the date when they were beginning to make new growth, they were sprayed with a solution of lime-sulphur and nicotine. This routine spraying was carried out weekly until the end of April. After this period it was not possible to spray all the plants since the direct inoculations were due to begin. However, the control plants and those which were not being inoculated at any particular period were sprayed throughout the season. The control plants actually received twenty applications. The spray formula had to be modified from time to time, especially during spells of hot weather, but the formula most generally used was $\frac{1}{2}$ fluid oz. nicotine, 5·7 gm. sulphonated lorol, and 8 fluid oz. of lime-sulphur in $2\frac{1}{2}$ gallons of water.

Source of Aphides and Mites.

All the Delicate Strawberry Aphides used for making the direct inoculations were the progeny of those used in the previous experiment. The aphides had been kept under glasshouse conditions during the autumn and winter months. The mites used were also the progeny of those in the earlier experiment and were kept under similar conditions.

Direct Inoculations.

The direct inoculations were made with a view of determining whether the virus could be transmitted from diseased to healthy plants when the aphides were breeding most freely, namely, in May, June and July. Thirty plants were used in each experiment. Thus during May ten plants were inoculated with aphides from virus plants, ten with aphides from healthy plants and a similar number were left untreated as controls. The same procedure followed for the June and July experiments. Each plant was inoculated once only, the inoculation being made on the first Wednesday in the month in each case, *and only five aphides were transferred to the plant to be inoculated whether they established themselves or not.*

These aphides were allowed to feed on the plants for one month, after which the small colony which had been produced was killed off by the application of nicotine sprays.

As found previously this method of making the direct inoculation under natural conditions (without the use of cages) again proved to be quite workable, though it may appear to be somewhat strange that the aphides did not migrate to adjacent bays and establish themselves there. No doubt the routine spraying of the plants and the ground and also the frequent moving of the soil helped materially in checking their spread.

In view of the fact that negative results had been obtained in all previous mite transmission investigations, it was decided to conduct mass inoculations in this experiment, and also not to limit the time of the inoculations to any particular month of the year. The initial mite inoculations were made during the first week of May and were continued weekly until the end of August.

Survey of Plants.

The plants were examined regularly throughout the season in order that any stray insects might be noted before they became established, and to ensure that the control plants were free of insect life. It so happened that the control plants remained free

from attack throughout the season, with the exception of a minor outbreak of a small blue weevil (*Rhynchites germanicus* Hb.) which was noted feeding upon the stolons of some of the plants, and Lady-bird Beetles were the only other insects detected.

Treatment of Plants.

The plants were watered twice daily when this was necessary. All the runners were removed systematically as they were formed until the end of May. At this period one sturdy runner was selected on each plant, and was rooted in a three-inch pot, which was plunged in the soil adjacent to the parent plant, the runner remaining attached to the parent by the stolon. All subsequent runners were removed from time to time. These selected runners which were left attached to the parent plant were not inoculated with aphides or mites, but small colonies were frequently found on them. These probably originated from individuals which had strayed from the parent plants.

All the soil around the plants and between the bays was hoed once a week with the object of checking the migration of the aphides and mites from one bay to another. In addition the ground was frequently soaked with a strong solution of lime-sulphur and nicotine as a further precaution.

Spread of Aphides and Mites.

As might be reasonably expected the aphid population on the inoculated plants was not so great as in the previous experiment. This may be accounted for because the five initial aphides transferred to each plant had only one month in which to breed and then the entire colony was destroyed. The aphides, however, established themselves sufficiently to cause conspicuous leaf curl, while the runner of each plant also became infested. At one period it seemed likely that the July inoculations were not going to produce large colonies of aphides, but by the end of the month the infestation proved to be similar to that of the May and June inoculations.

As in the previous season's investigations the winged forms of the aphides were noted towards the end of July, and it was feared that they might migrate from one bay to another. So again large glass frames were erected between the healthy and diseased aphid bays as a precaution.

Examination of Plants.

Three complete surveys of the plants were made in June, August and October. The June survey showed little of interest. All the plants were growing well and there was little difference in the appearance of the plants in the various bays.

In the August survey two features were outstanding. The first was the marked difference in appearance of the foliage of the mite- and aphid-infected plants. The mite-infected plants (including mites-from-healthy and mites-from-diseased-plant series) exhibited characteristic leaf wrinkle, and their leaves were much duller in appearance than those of the aphid-infested and control plants. The aphid-infested plants on the other hand showed the typical aphid leaf curl, but the foliage still remained a rich green colour.

The second interesting feature was the appearance of the plants with aphides from diseased plants. The plants inoculated in May were already exhibiting characteristic " Yellow-edge " symptoms, while those inoculated in June were beginning to show similar symptoms. Those inoculated in early August were as yet not showing any virus symptoms, and were very similar in appearance to the control plants.

Curiously enough one plant in the aphids-from-healthy-plant series exhibited typical "Yellow-edge" symptoms, and by a coincidence it happened to be plunged in the same position on the plot as the plant which last year also showed virus symptoms. The plant happened to be the end one in the bay adjoining the aphids-from-diseased-plant series.

Height and Spread Records.

Height and spread measurements were obtained on three occasions, and it was found that the slight variations in the height and spread of the plants of all series in the first two records does not warrant their inclusion here. The figures indicate, however, that the plants were uniform in size during the earlier part of the investigation. The final height and spread records were obtained during the second week of October. The figures indicate some very distinct differences between some of the different sets of plants. These measurements are presented in the following table :

Table showing Height and Spread of Royal Sovereign Strawberry Plants and their Runners.

Inoculated with	Parent Plants.		Runners.	
	Average Height (inches).	Average Spread (inches).	Average Height (inches).	Average Spread (inches).
Mites from Virus Plant	5·4	16·8	3·4	9·7
Mites from healthy Plant	5·9	17·5	2·8	9·9
Control (Series 1)	5·1	17·2	2·9	10·3
Control (Series 2)	5·4	17·3	2·8	10·1
Aphides from healthy Plant (May) ..	5·2	16·6	2·5	10·1
Aphides from healthy Plant (June) ..	5·0	16·0	2·6	8·4
Aphides from healthy Plant (July) ..	5·3	16·5	2·8	9·0
Aphides from Virus Plant (May) ..	3·9	14·8	1·5	7·3
Aphides from Virus Plant (June) ..	3·4	14·7	1·5	8·3
Aphides from Virus Plant (July) ..	4·5	16·1	1·7	8·6

Unfortunately it is not possible to show the very clear cut differences between the various treatments in a table of this nature, but the figures suffice to show some interesting points.

In the first place it will be noted that there is practically no difference in the height and spread records of the two series of mite inoculated plants and of the controls. This always applies to the plants inoculated with aphides from healthy plants and the controls. The differences stand out when the figures for the plants inoculated with aphides from virus plants are examined. It will be noted that both the height and spread measurements of the plants inoculated in May and June are considerably less than for the remainder of the plants in the experiment. It is also of interest to examine

the figures for the month of July in the aphids-from-virus-plant series. It will be seen that the height and spread records of these plants differ little when compared with those of all the other series. Now this may be explained by the fact that although each of these plants and their runners were exhibiting typical virus symptoms, the actual inoculations were not made until July (whereas the other two series were inoculated in May and June respectively), and therefore the virus had not had sufficient time to check the growths of the plants to the same extent as those inoculated earlier.

Finally, it should be noted that the aphides-from-healthy-plant series proved to be just as vigorous as the control plants. This fact tends to support last year's observations which indicated that the aphides alone caused very little injurious effect upon the plants, with the exception of the peculiar leaf curling symptoms which are a sure manifestation of aphid attack.

Field Observations.

As already mentioned the aphid inoculations were made during the first week of May, June and July respectively, and only five aphides were transferred to each plant.

As noted above one of the plants inoculated with aphides from a healthy plant produced typical virus symptoms. Two other plants in this series were also marked as being suspicious cases in September, but " Yellow-edge " symptoms had not developed by the end of the year when the plants were again quite normal in appearance.

All the plants inoculated with aphides from a virus plant in May began to exhibit " Yellow-edge " symptoms by 27th July, 1935 and by 8th August the symptoms were very pronounced on each of the ten plants and their runners. Of those inoculated in June (from a virus plant) symptoms first began to appear by the 6th August, but they were much more striking by the 16th of the month.

Those inoculated with aphides from a virus plant in July did not exhibit definite symptoms until the 16th August but it was not until the end of September that the characteristic " Yellow-edge " symptoms were fully apparent. It is to be noted, however, that they were not so pronounced as those of the May and June series.

It should be mentioned that the control plants (60 in all) remained healthy, and that while both series of mite plants were showing traces of direct mite injury upon the foliage, no virus symptoms were present. The aphides-from-healthy-plant series also remained free from " Yellow-edge " apart from the one exception already referred to.

A Note on the Scientific Names of the Strawberry Tarsonemid Mite and the Strawberry Aphid.

Confusion has existed for some time regarding the correct scientific names of the Strawberry Mite and the Aphid. A comparison of the English and American species of Strawberry Tarsonemid Mites has been made by Dr. H. E. Ewing and Dr. Floyd F. Smith,* of the United States and they have shown that the species are identical. In this country the mite has been referred to as *Tarsonemus fragariae* Zimm., while in America and Canada it is known by the name of *Tarsonemus pallidus* Bks. The American name claims priority; thus the correct name of the mite is *T. pallidus* Banks, while *T. fragariae* Zimm. must be regarded as a synonym.

* The European Tarsonemid Strawberry Mite Identical with the American Cyclamen Mite. Ewing, H. E. and Smith, F. F., *Ent. Soc. Wash.*, 1934, 36. No. 8 and 9, 18th February, 1935.

The Delicate Strawberry Aphid (*Capitophorus fragariae* Theo.) and the American Strawberry Aphid (*Myzus fragaefolii* Cockll.) are also considered to be identical, and the correct name of the species is considered to be *Capitophorus fragaefolii* Cockll. The writer is much indebted to Mr. F. Laing of the British Museum for his assistance in determining the name of the aphid.

Summary.

1. Further investigations on the transmission of the strawberry " Yellow-edge " virus are described.

2. The Delicate Strawberry Aphis (*Capitophorus fragaefolii* Cockll.) is again shown to be a vector of " Yellow-edge ", thus confirming the results obtained in 1934.

3. Transmission of the virus by the aphis has been made during the months of May, June and July respectively.

4. Five aphides proved to be sufficient to transmit the virus from a diseased to healthy plant, and virus symptoms began to appear seven weeks after the inoculations were made.

5. Direct Aphid injury, while showing characteristic symptoms, did not cause any damage to the plants.

6. Attempts to transmit the virus by means of the Strawberry Tarsonemid Mite (*Tarsonemus pallidus* Banks) gave negative results.

7. The scientific names of the aphid and mite are discussed in brief.

STUDIES OF IMPREGNATION OF TREE BANDING MATERIALS*

II. APPLE BLOSSOM WEEVIL AND CODLIN MOTH EXPERIMENTS IN 1935

A PROGRESS REPORT

By R. M. GREENSLADE and A. M. MASSEE

INTRODUCTION.

The tree banding experiments undertaken in 1934 in relation to the control of Apple Blossom Weevil and Codlin Moth, indicated that certain preparations when impregnated into the bands served as attractants. In view of the results obtained last season, the investigation has been continued this year, and all the tree banding materials used in the initial experiment have been included again, with the addition of a β-naphthol treatment similar to that used successfully in the United States of America and in Australia for codlin moth control.

The trial was carried out in a five acre bush apple orchard situated at East Malling. This orchard consisted of some five hundred trees of the varieties Bramley's Seedling, Newton Wonder and Lane's Prince Albert. Three-fifths of the orchard contained Bramleys and Lanes planted alternately, while the other portion contained Newtons and Lanes planted in a similar manner. The majority of the trees were uniform in size. The ground under them was tractor cultivated. This orchard proved to be ideal for the experiment since both codlin moth and weevil were known to be abundant there the previous summer. The following treatments were used in the investigation :

Treatment No.	
1–8	33% Seekay Wax AX.111 in trichlorethylene.†
9–10	50% ,, A.68 ,,
11–12	50% ,, A.93 ,,
13–14	33% ,, A.123 ,,
15	10% ,, A.68 in orthodichlorobenzene.
16	10% ,, A.68 +30% paradichlorobenzene in trichlorethylene.
17	20% ,, in creosote oil.
18	7% tetrachlorbenzene in trichlorethylene.
19–26	37% β-naphthol in lubricating oil.
27	Untreated control bands.

* This first report on this work appeared in the *E. Malling Res. Sta. Ann. Rep. for* 1934 (May, 1935), 180-4.

† The preparations used were supplied by Imperial Chemical Industries Ltd. At present they are only under trial and are not on the market. The " Seekay " waxes are a series of chlorinated naphthalenes.

All the bands were put on the trees on the 21st June, 1935, the various treatments being randomized in the usual way so that the effect of any treatment could be noted on the different varieties.

The Application of the Bands.

Some of the treatments made the bands somewhat greasy, so that their application was rather difficult, but none of the treatments proved to be as objectionable as those tried in 1934. The β-naphthol bands in particular were unpleasant to put on since they caused a slight irritation to the hands, face and eyes, this effect being more pronounced on very hot, dry days. Of the other treatments, number 16 was also somewhat objectionable on account of the unpleasant smell, which, however, passed off after the bands had been on the trees a few days. The rest of the bands went on readily and were not unpleasant to apply.

Damage to Bands by Birds, Mice, etc.

The records show that birds began to " work " the bands during August, and by the end of September a few of the bands were very severely pecked. There is little doubt that more than one species was responsible for destroying the bands, but schools of Great Tits were frequently observed working the bands while searching for the codlin moth larvae hibernating in them. As might be expected the untreated control bands were damaged most, but some of the treated bands were slightly or moderately pecked also. Of the trees with a crop in treatment 1-8, a number received medium to heavy damage, as also did those of treatments 13-14, and 15. The other bands received little or no damage. The β-naphthol bands were quite undamaged when removed.

It is of interest to note that the Great Tits were very definitely searching for the codlin moth larvae only, since the bands on the trees without a crop were very rarely damaged, and the bands containing weevils but no codlin moth larvae also remained intact.

The Effect of the Treated Bands on the Trees.

It will be remembered that in the previous experiment, only a limited number of treated bands were placed on the stems of the trees in view of the possibility of damaging the bark. Since no trace of damage was noted, however, it was decided to put all the bands on the trees in 1935. Every band was examined weekly so that any form of injury could be noted without delay. It so happened that none of the treatments caused any damage at all to the stems of the trees nor did any of them discolour the bark or tend to soften it as some chemicals are said to do. This was indeed very encouraging since it might well be expected that at least some of the treatments would have caused some slight damage. In another small trial which will be referred to later on, severe damage was caused to the bark of some apple trees by chemically treated bands. This indicates the necessity for caution before new treatments are applied on a large scale.

Field Records and Removals of Bands.

In addition to obtaining records of bird damage and the effects of the actual treatments on the trees, it was decided to obtain records of the cropping and

non-cropping trees. As will be seen later, this record proved to be a very important one. The crop in the orchard was not very large owing, no doubt, to the severe frost earlier in May. There was quite a sprinkling of apples, however, on some of the trees of all three varieties, while others bore no crop at all. The crop records were divided into two groups, namely, trees with a crop, and trees without a crop.

The removal of the bands commenced on 1st October and was completed on the 10th of the month. The examination of the bands proceeded slowly, since complete details were obtained of the number of weevils and codlin moth larvae present in them, and also those left behind on the tree trunks. In addition, an inventory was made of most other insects present whether they were of economic importance or not. Here it may be mentioned that many interesting insects were found in the bands and these will be referred to in a separate report.

The Effects of the Treatments upon Weevil and Codlin Moth Larvae.

Tables I and II present a full summary of the averages of the weevils and codlin moth larvae in the bands, and those on the trunks under the bands. For convenience, the Tables have been arranged so that the weevils and codlin moth larvae on the trees with a crop can be compared with those on the trees without a crop.

In the first place it will be noticed that there is very little variation in the weevil population on the cropping and non-cropping trees. This point is of interest when the figures are compared with those in the codlin moth columns. It shows up quite clearly that the larvae were mainly confined to the trees bearing a crop, which was to be expected, while the weevils were more inclined to move about in the orchard after they had emerged from the "capped" blossoms. This view was supported by the characteristic damage to the foliage caused by the feeding of the weevils before they found suitable resting places.

It will also be noted that 33 per cent. "Seekay" Wax AX.111 in trichlorethylene, treatment 1-8, proved to be the most attractive to the weevils. This is of particular importance since this same treatment was the outstanding one last year. This treatment did not attract codlin moth larvae to the same degree but it is evident from the tables that the treatment did not deter the larvae from entering these bands.

Table I.

Trees with no Crop.

Treatment.	Weevil.		Codlin Moth Larvae.	
	Average No. in band.	Average No. on tree.	Average No. in band.	Average No. on tree.
1–8	98·8	20·9	5·2	6·0
9–10	12·9	7·2	3·6	3·3
11–12	34·1	18·3	3·9	5·1
13–14	81·4	39·2	4·0	6·8
15	33·7	10·3	7·2	14·7
16	38·4	13·1	6·5	13·8
17	1·2	21·1	2·2	4·8
18	82·3	3·9	1·3	1·4
19–26	0·3	5·7	4·9	2·9
27	57·7	14·9	4·5	4·7

Table II.

Trees with Crop.

Treatment.	Weevil.		Codlin Moth Larvae.	
	Average No. in band.	Average No. on tree.	Average No. in band.	Average No. on tree.
1–8	91·1	87·5	27·4	36·8
9–10	12·4	11·2	49·5	50·4
11–12	23·1	10·7	47·5	45·3
13–14	62·4	16·5	27·6	43·0
15	26·9	12·5	47·9	50·0
16	30·2	21·1	25·1	61·7
17	1·8	7·3	28·9	45·7
18	52·3	8·0	37·3	40·2
19–26	0·1	6·3	46·3	28·7
27	23·9	7·9	17·6	14·6

It will be seen that an average of 27 larvae was found in the bands of the trees with a crop, while only five occurred in those where there was no crop.

Of the other treatments 13-14 (33 per cent. " Seekay " Wax A.123 in trichlorethylene) was again outstanding, an average of 81 weevils occurring in the bands of the trees with a crop. In this treatment it will be noted that roughly the same number of codlin moth larvae was found as in the case of treatment number 1-8.

None of the other treatments proved to be attractive to the weevils with the exception of 7 per cent. tetrachlorbenzene in trichlorethylene (treatment 18) and this was found to attract an average of 82 weevils per band. In the previous trial an average of only 5 weevils occurred in the bands of this treatment. This year there was double the amount as compared with the control, whereas in last year's experiment, the totals were about equal.

Another point of interest is the fact that none of the treatments deterred codlin larvae from going into the bands. Some treatments, however, were better attractants than others. One of the best proved to be 50 per cent. " Seekay " Wax A.68 in trichlorethylene (number 9-10), while 10 per cent. " Seekay " Wax A.68 in orthodichlorobenzene (number 15) and 37 per cent. β-naphthol in a lubricating oil (19-26) also proved to be attractive to codlin moth larvae. (See Table II.)

The result obtained with the β-naphthol bands agrees with the results obtained in the United States of America.

Table III indicates the treatments which were attractive to codlin moth larvae and weevils in 1934 and 1935, and also, the treatments which deterred the weevils.

Table III.

Treatments Definitely Attractive to Codlin Moth Larvae.

1934.	1935.
50% Seekay Wax A.68 in trichlorethylene.	50% Seekay Wax A.68 in trichlorethylene.
50% ,, A.93 ,,	10% ,, A.68 in orthodichlorobenzene.
33% ,, AX.111 ,,	50% ,, A.93 in trichlorethylene.
	10% ,, A.68 +30% paradichlorobenzene in trichlorethylene.
	β-naphthol.
Codlin moth larvae not deterred by any treatment.	Codlin moth larvae not deterred by any treatment.

TABLE III—*continued*

TREATMENTS ATTRACTIVE TO WEEVILS.

1934.	1935.
33% Seekay Wax AX.111 in trichlorethylene.	7% Tetrachlorbenzene in trichlorethylene. 33% Seekay Wax AX.111 in trichlorethylene. 33% ,, A.123 ,,

WEEVILS DETERRED BY TREATMENTS.

1934.	1935.
50% Seekay Wax A.68 in trichlorethylene. 50% ,, A.93 ,, 10% ,, A.68 in orthodichlorobenzene. 10% ,, A.68 +30% paradichlorobenzene. 20% ,, in creosote oil.	β-naphthol. 20% Seekay Wax in creosote oil. 50% ,, A.68 in trichlorethylene.

TREATMENTS IN ORDER OF ATTRACTIVENESS.

The attractiveness of certain treatments to weevil and codlin moth larvae is very striking as shown in the following Table.

TABLE IV.

Order of attractiveness of bands to Weevil and to Codlin Moth larvae on Trees with a Crop. Average number of Weevil and Codlin Moth larvae per tree, in band and on bark under band.

Treatment.	Weevil.	Treatment.	Codlin Moth Larvae.
1–8	118·6	9–10	99·9
13–14	79·0	15	98·0
18	60·25	11–12	92·8
16	51·3	16	86·8
15	39·4	18	77·5
11–12	38·9	19–26	75·0
27 (controls)	31·8	17	74·6
9–10	23·5	13–14	70·6
17	9·1	1–8	64·3
19–26	6·4	27 (controls)	32·2

Thus it will be seen that on trees bearing a crop (Table IV) treatment 1-8 attracted an average of 118 weevils ; treatment 13-14, 79 weevils ; and treatment 18, 60 weevils. The above also attracted 64, 70 and 77 codlin moth larvae per band respectively. It will also be noted that treatment 9-10 attracted 99 codlin moth larvae and 23 weevils, and the β-naphthol treatment (No. 19-26) an average of 75 larvae, but only 6 weevils.

It is clear therefore that the treatment 19-26 (β-naphthol) actually deterred the weevils from entering the bands. (See Tables IV and V.)

TABLE V.

Order of attractiveness of bands to Weevil and Codlin Moth larvae on Trees with NO *Crop. Average number of Weevil and Codlin Moth larvae per tree, in band and on bark under band.*

Treatment.	Weevil.	Treatment.	Codlin Moth Larvae.
1–8	119·7	15	21·8
13–14	101·0	16	20·2
18	86·2	1–8	11·5
27 (control)	72·6	27 (control)	9·3
11–12	52·4	11–12	9·1
16	51·5	19–26	7·9
15	44·0	9–10	7·0
17	22·3	17	7·0
9–10	20·1	13–14	5·4
19–26	6·0	18	2·7

It has come to the authors' notice that in certain circumstances the weevils will actually hibernate in β-naphthol treated bands, and it is proposed to investigate this matter in more detail at some future time.

PHYTOCIDAL TESTS OF A NEW SERIES OF CHEMICALLY TREATED BANDS.

A small initial experiment was carried out in August, 1935 to discover if certain organic thiocyanates caused any phytocidal effects on the stems of apple trees.

When the bands were removed in November it was found that each of the treatments caused considerable damage to the stems, in many instances large areas of tissue being destroyed.

In addition it was noted that each of the treatments had kept away insect life generally, because such insects as earwigs, anthocorids and even spiders were almost entirely absent while weevils and codlin moth larvae were very scarce.

SOME NEW OBSERVATIONS ON THE 1934 BANDING EXPERIMENT.

When the Progress Report on the 1934 banding trial was published in the East Malling Report in May, 1935, certain observations were still being made on the codlin moth larvae taken from the bands, but at that time it was not possible to include the results of these observations.

The larvae were removed from the treated and control bands and were kept in tins in the laboratory. The larvae from the control bands pupated in their normal way and the moths had emerged by July. In this series, the mortality proved to be 17 per cent.

In the treated band series the mortality figures were variable. For instance, in the treatment which attracted most weevils, namely, the 33 per cent. " Seekay " Wax AX.111 in trichlorethylene, the mortality of codlin moth larvae was only 16 per cent. Again, in another treatment which also attracted the weevils, 33 per cent. " Seekay " Wax A.123 in trichlorethylene, the mortality of larvae was only 6 per cent. All the other treatments killed 100 per cent. of the larvae.

This aspect may not have much bearing on the problem in this country, but in climates which favour several generations of codlin moth larvae in one season, it would naturally be very important to kill off as many of the first brood as possible.

Codlin Moth Larvae Parasites.

In the course of these observations, two species of parasites were reared. One proved to be a Dipterous parasite of the family *Tachinidae*, named *Arrhinomyia tragica* Mg., and the other an Ichneumonid, *Ephialtes crassiseta* Thos. The parasites were identified by Mr. J. E. Collin and Mr. J. F. Perkins respectively. Both species appear to be somewhat local.

The writers are greatly indebted to Mr. S. W. Mayhew, Armstrong College, Newcastle-on-Tyne, and to Mr. R. G. Gambrill, Technical Assistant of the Section of Insecticides and Fungicides at East Malling, for their valuable assistance in helping to record the insects in bands.

Summary.

Details are given of the results obtained in the second season of the investigation on the control of Apple Blossom Weevil and Codlin Moth Larvae by attracting them into corrugated cardboard bands impregnated with various chemicals.

The treatments which proved to be successful in the initial trial have again been outstanding.

As in the previous experiment none of the treatments caused any damage to the stems of the trees.

β-naphthol treated bands were also included and gave promising results against codlin moth larvae, but in this particular investigation they were of little value for trapping the apple blossom weevil.

Apart from the organic thiocyanates examined this year for the first time, none of the treatments caused any damage to the stems of the trees. This confirms the results obtained in 1934.

A NOTE ON THE TREATMENT OF DORMANT NURSERY STOCK AGAINST WOOLLY APHIS

By R. M. GREENSLADE

DORMANT nursery stock which is infected by Woolly Aphis, *Eriosoma lanigerum* (Hausm.), is often cleaned by dipping the material in tar distillate wash or by fumigating with hydrogen cyanide. Staniland and Walton* in 1930 showed that a 10 per cent. solution of an old type of tar oil was effective but they did not consider fumigation satisfactory. Both methods are carried out in practice and are found fairly satisfactory, but doubts are often expressed as to the safety of these methods to the plant material, particularly with regard to the dipping of rootstocks. A small trial was planned, therefore, to determine the limits of safety to rootstocks, using extreme concentrations of dipping solution and of hydrogen cyanide gas. Two of the East Malling types of Paradise rootstocks were used, No. IX and No. XVI, as being early and late bud-breaking varieties respectively.

DIPPING EXPERIMENT.

The following treatments were applied :

Tar-oil wash at 10%, 20%, 25%, 50%.
Tar-oil wash at 5% +0·1% of a commercial wetting preparation.
Control (untreated).
Soft Soap 20 lb. per 100 gallons.
Soft Soap 30 lb. per 100 gallons.
A commercial wetting preparation at 0·1%.
Control (untreated).

Ten stocks of each type were dipped, in bundles, in each treatment for 20 seconds, drained for 10 minutes, roots upward, and planted out the following day, 12th February, 1935. The state of growth of these stocks was then observed at regular intervals from 1st March to the end of July.

The No. IX stocks which were untreated began to show opening of the outer bud scales by 6th March, the first buds were open on the 29th March and all buds were open by the 8th April. In comparison with the controls the growth of No. IX stocks treated with 10 per cent. tar oil was retarded by a few days, of those treated with 20 per cent. tar oil by two weeks, with 25 per cent. by six weeks and with 50 per cent. by more than seven weeks.

By the end of May all stocks except those treated with 50 per cent. tar oil were indistinguishable from the controls.

The untreated No. XVI stocks did not begin to grow until 3rd May and all buds were open by 30th May. All the other stocks of this type behaved similarly to the controls except that those treated with 50 per cent. tar oil, though not later than the others, remained stunted.

* Staniland and Walton. *Ann. Rep. Long Ashton Res. Sta.*, 1930. 106-7.

Fumigation Experiment.

Fumigation was carried out in a closed box in which the air was kept moving by a small fan, the stocks being raised off the bottom. The temperature of the air in the box varied very little from 12° C. during the period of the fumigations. At each concentration twenty stocks of each type were used, ten of each being comparatively dry, as lifted from the ground, and ten being thoroughly sprayed with water before fumigation. The gas was generated from sodium cyanide and sulphuric acid used in amounts representing 4, 8, 16 and 32 oz. sodium cyanide per 1,000 cubic feet. The Ministry of Agriculture recommendation for dormant fruit trees is 2 ozs. per 1,000 cubic feet. (Advisory Leaflet, No. 92.) The stocks were left for 2½ hours in the fumigation box and planted out on the 28th February.

Records were taken similar to those for the dipping experiment and it was found that all the stocks behaved in the same way as the untreated control stocks.

Conclusion.

It is evident from these results that apple rootstocks may safely be fumigated at more than the recommended concentration of hydrogen cyanide without ill effect on their subsequent growth, and that the wetness of the stocks at the time of fumigation does not affect the result. Stocks may also be dipped in tar oil wash of 10, 20 or 25 per cent. concentration without permanent injury, though growth of the No. IX stocks was retarded by the higher concentrations. That No. XVI was not affected by these concentrations is probably due to the fact that in February they were still completely dormant whereas the No. IX were not. A concentration of even 50 per cent. only stunts the growth of the stocks slightly so that concentrations necessary to wet Woolly Aphis (i.e. about 10 per cent.) can be used with perfect safety.

Summary.

Experiments were carried out to determine what concentrations of certain spray solutions and of hydrogen cyanide gas are injurious to dormant apple rootstocks.

It was found that the concentrations recommended for use against Woolly Aphis on dormant stock have no ill effect on the subsequent growth of the rootstocks and that very much higher concentrations can be used without permanent damage.

INSECTICIDES AND FUNGICIDES

OBSERVATIONS ON CODLIN MOTH *(CYDIA POMONELLA* L.*)* IN 1935

By W. STEER

SINCE the object of this report is merely to record observations made on Codlin Moth at East Malling in 1935, no attempt has been made to review the very extensive literature which deals with the life history and control of this pest.

EMERGENCE OF THE MOTHS.

In order to determine the time and duration of the emergence period of the moths, several hundred larvae were collected in the autumn and winter of 1934-5 and kept under observation. For this purpose cages were used which measured about a foot square in plan and 3 feet in height ; they were made partly of glass and partly of fine mesh phosphor bronze wire on wooden frames. Each cage was erected around a wooden post driven partly into the ground. The larvae were placed in strips of sacking and corrugated paper wound around the posts. Since the cages were erected out-of-doors the larvae were kept under approximately natural conditions of temperature and humidity.

Daily records were made of the numbers of moths which subsequently appeared in the cages (see Fig. 1). Emergence began on 28th May and continued till late in July (one moth being found as late as 24th July), but most of the moths (93 per cent.) emerged during June. The varying weather conditions were apparently responsible for much of the day to day fluctuation in the emergence curve, moths appearing in greater numbers and showing much more activity on warm, sunny days than on cool, dull days. Emergence took place during the day time, never during the night.

The emergence period has been studied by other workers, notably by Adkin (2) and by Buckhurst (3). Adkin found that the chief emergence of the moths occurred during the last week in June and the first fortnight in July, his earliest record being 16th June (in 1933) and his latest 30th July (in 1930). Buckhurst found that, in 1921, the moths were on the wing in early June.

EGG LAYING.

The data obtained here in 1935 were insufficient to show just when egg laying began but this was probably before the middle of June. It was at its height during the last week in June and the first week in July, and continued throughout July into August, some unhatched eggs being found (on pears) as late as 13th August. Buckhurst (3) states that he found eggs laid by first generation moths in the middle of June.

The eggs were laid anywhere on the surface of the fruits and, quite often, on the leaves also. This agrees with the observations of Buckhurst (3) and of Adkin (1, 2).

Entry into the Fruit.

Newly hatched larvae were first noticed attacking the fruits on 1st July, though some larvae had evidently hatched a few days before this date.

On apples the larvae entered the fruits chiefly at the side, very few entering at the eye or by the side of the stalk. On pears, however, entry was made almost invariably through the eye. Side entry was seldom seen on pears and then, usually, only in fruits which were beginning to soften. These observations entirely agree with those of Adkin (1, 2), but differ from those of Buckhurst (3) who found that eye entry was the rule for the first, and side entry the rule for the second generation. Some observers have reported that, in 1935, eye entry was the more prevalent on apples, others that side entry predominated. Some growers state that eye entry was usual on Newton and side entry on Bramley. Other growers have reported variously that, on Newton, side entry was as common or commoner than eye entry. Although side entry was undoubtedly the commoner mode of attack on apples at East Malling (no Newtons were available for observation), it seems that the habits of the larvae may differ to some extent on certain varieties and, possibly, in different localities.

The usual manner of entry as observed on apples was as follows. The young larva pierces the skin and so enters the side of the apple. It then eats out a round shallow cavity beneath the skin, pushing its frass out of the tiny entrance hole. The skin over this cavity turns dark and eventually blackens and the attacked area soon becomes a depressed blackish or brown spot up to about 4 mm. in diameter. The larva eventually tunnels farther into the fruit and feeds on the core and surrounding flesh until fully fed. When it leaves the fruit it may make a fresh gallery but frequently it retraces its steps and leaves at the spot where it originally entered, rupturing the small round flap of skin to do so. The manner of entry, as observed here in 1935, was thus identical with that described by Adkin (1).

The Second Generation.

A good deal of confusion has arisen in recent years with regard to the number of "broods" or generations which occur in this country. Side entry has often been thought to be associated largely with the second generation and the later larvae of the first generation have consequently often been termed the "second" generation.

Indications were obtained in 1934 that the second generation larvae do not appear till early September. To obtain more precise information weekly collections of mature larvae were made in 1935 as soon as the larvae began to leave the fruits.

Apple and pear trees were provided with bands of sacking round the stem and pieces of sacking in the crotch. The larvae were collected from the sacking at weekly intervals and transferred to emergence cages, there to complete their development.

Fig. 2 shows that larvae began to enter the sacking at an earlier date on apples than on pears. This agrees with observations made in June and July that egg laying and fruit attack are later on pears than on apples. The whole of the pear crop on the trees used for this work was picked on 19th September and the movement of the latest batches of larvae could not therefore be studied on pears after that date.

Only one moth developed from the whole of the larvae collected. This emerged on 27th August from the material collected on 2nd August. Search in the plantations and the examination of fruit brought into the packing shed failed to reveal any trace of a second generation.

It is clear, therefore, that no second generation occurred at East Malling in 1935, although there appears to have been one in each of the two preceding years.

Control Measures.

Owing to the almost complete loss of the apple crop following the frost of 17th May, it was not possible to do any spraying trials on apples in 1935. A small trial of lead arsenate, derris and nicotine was, however, carried out on a row of sixteen Conference pear trees.

The sprays were applied on 10th July by means of a "Cascade" hand-pump machine supplying a single nozzle at a pressure of about 200 lb. Four trees, chosen at random, were sprayed with each spray, care being taken to wet all parts of the fruits thoroughly. The details of the sprays used, together with the results obtained, are shown in Table I.

Hatching was in full swing at the time of spraying and many larvae had already entered the fruits. Egg laying was not yet over and continued, probably, till early August, since some unhatched eggs were found as late as 13th August.

The lead arsenate, on drying, left a good deposit in the eye and gave also a fairly good cover of most of the fruits. Nicotine was used in this trial as it was thought that such a spray, applied on a hot sunny day, might reach those larvae which had just entered the fruits and, possibly, kill the unhatched eggs also. Derris was used in the hope that it would be as effective as lead arsenate but less likely to leave an objectionable deposit on the fruit.

The whole of the fruit, including the windfalls, was examined at picking time with the result shown in Table I.

Table I.

Treatment.	Total No. of Fruits.	No. Damaged by Codlin Moth Larvae.	Per cent. Damaged.
Controls (unsprayed)	1,435	197	13·7
Lead arsenate (4 lb.)* + Lethalate Wetting preparation (1 lb.) ..	1,123	31	2·8
Derris (2 lb.)† + Soap (5 lb.)	1,209	138	11·4
Nicotine (8 oz.) + Soap (5 lb.)	1,176	104	8·8

Thus lead arsenate considerably reduced the damage (from 13·7 to 2·8 per cent.) but indifferent results were obtained with Derris and with nicotine. Confirmation of these results was obtained from figures of larvae trapped on the trees, the numbers of larvae caught in sacking bands on control trees and on trees sprayed with lead arsenate, with Derris and with nicotine being respectively 28, 3, 29 and 19.

At the time of picking it was difficult to find any trace of a visible deposit on the fruits which had received lead arsenate. Chemical analyses revealed a minute amount of arsenic—less than 0·001 grains per pound of fruit, which is less than one-tenth of the tolerated limit.

Codlin Moth control on pears is not likely to prove difficult since the calyx lobes remain open much longer than on apples and it is thus an easy matter to fill the eye with a deposit of lead arsenate. It would be unnecessary to maintain a deposit of poison on the sides of the fruit if, as seems likely, the larvae normally eat their way into the pear at the eye.

* The amounts shown are all per 100 gallons of spray.

† The Derris used was similar to that used in the 1934 Raspberry Beetle experiments (i.e. crude rotenone content 3·6 per cent.).

The control of Codlin Moth on apples presents a more difficult problem since the prevalence of " side entry " requires a deposit of poison to be maintained on the sides of the fruit at a time when the apples are rapidly increasing in size. For maximum effectiveness, therefore, spraying needs to be carried out as late as possible.

The emergence records obtained in 1935 (see Fig. 1) suggest that the second post blossom (" three weeks ") scab spray is the earliest to which lead arsenate need be added. This spray would have been early enough if applied four or five weeks after petal-fall in 1935, since larvae did not begin to attack the fruit before the end of June. It is doubtful, however, whether such a spray would leave a deposit which would persist and so protect the fruits throughout the period during which they are liable to attack. An additional, later spraying may, therefore, be found necessary. It is not known how late lead arsenate can, under our conditions, be applied without some risk of finding at picking time that the fruit bears an undesirable deposit.

Lead arsenate applied at petal-fall is likely to affect Codlin Moth only where a big proportion of the larvae goes in at the eye. In those areas where eye entry commonly occurs lead arsenate should be added to the petal-fall scab spray.

The results of experiments with chemically treated trapped bands are described elsewhere in this Report.*

Acknowledgment.

The earlier part of this work was carried out with the assistance of Mr. F. J. D. Thomas whilst he was on the staff of the Station. Thanks are also due to Dr. H. Shaw who examined the arsenic residues on the pears.

Summary.

An account is given of some observations made at East Malling in 1935 on the habits of the Codlin Moth (*Cydia pomonella* L.).

Most of the moths emerged during June and laid eggs on fruits and foliage during June, July and part of August. Larvae began to attack the fruit at the end of June, entering pears almost always through the eye and apples mostly at the side. Fully fed larvae began to leave the apples late in July and continued to do so till the end of September, most of them leaving in the middle of August. The larval movements were similar on pears but occurred nearly a fortnight later.

No second generation occurred in 1935.

Lead arsenate, applied on 10th July, gave good results on pears, reducing the damage from 14 to 3 per cent. Nicotine and Derris each gave indifferent results.

Control measures are discussed in the light of our present knowledge and it is suggested that lead arsenate be added to the second post blossom scab spray and applied, preferably, four or five weeks after petal-fall. The addition of lead arsenate to the petal-fall scab spray is advisable where eye entry of the fruit is prevalent.

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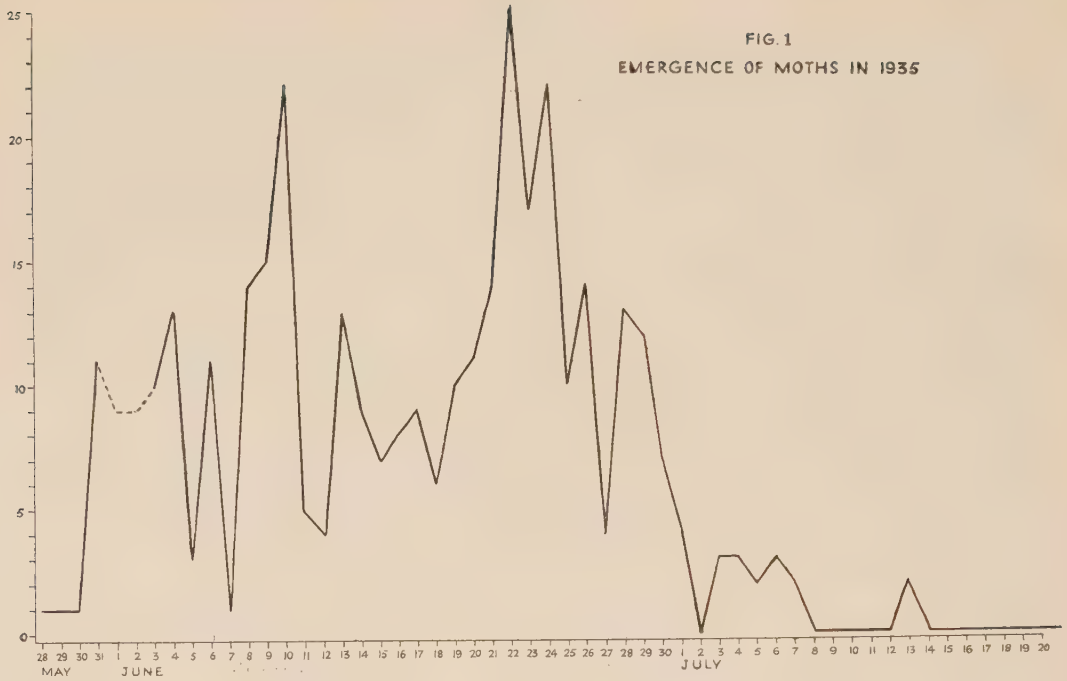


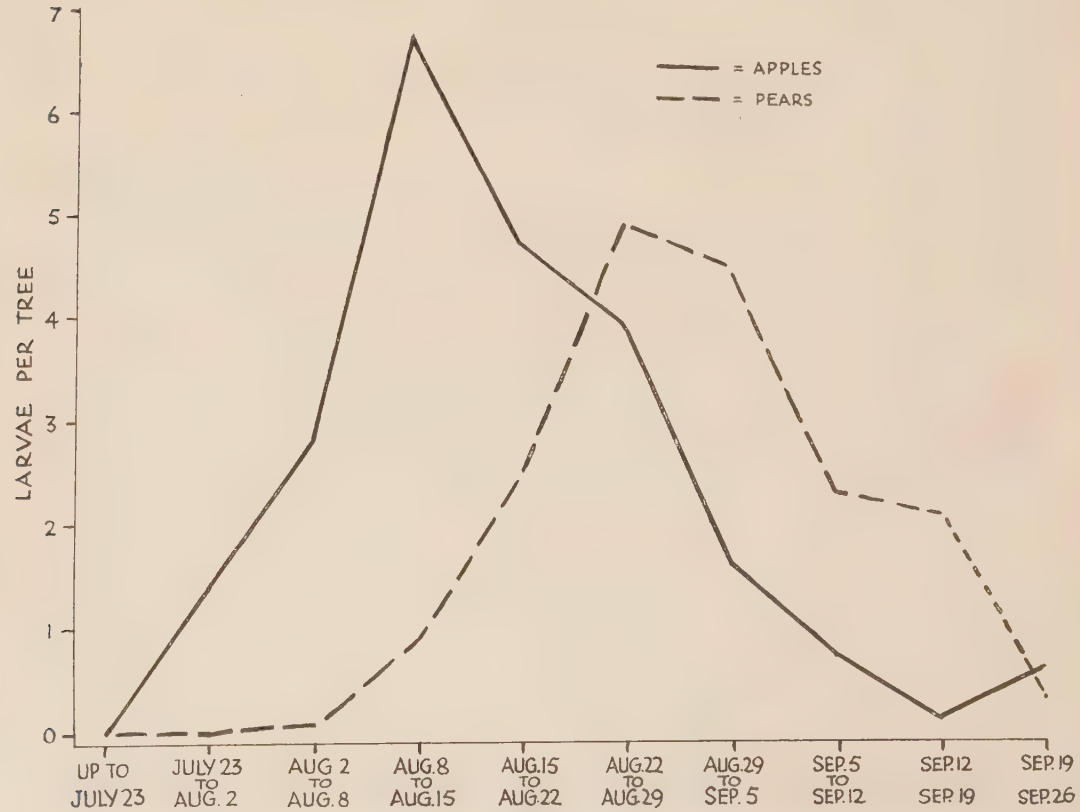

= APPLES
= PEARS
LARVAE PER TREE
UP TO JULY 23
JULY 23 TO AUG. 2
AUG 2 TO AUG. 8
AUG. 8 TO AUG. 15
AUG. 15 TO AUG. 22
AUG. 22 TO AUG. 29
AUG. 29 TO SEP. 5
SEP. 5 TO SEP. 12
SEP. 12 SEP. 19
SEP. 19 SEP. 26

FIG. 2.
Showing periods during which larvae left the fruit to seek shelter in sack bands on apples and pears in 1935.

A FIELD SPRAYING TRIAL OF COMBINED FUNGICIDE-CONTACT-INSECTICIDE SPRAYS IN 1935

A PROGRESS REPORT

By M. H. MOORE and H. B. S. MONTGOMERY

Introduction.

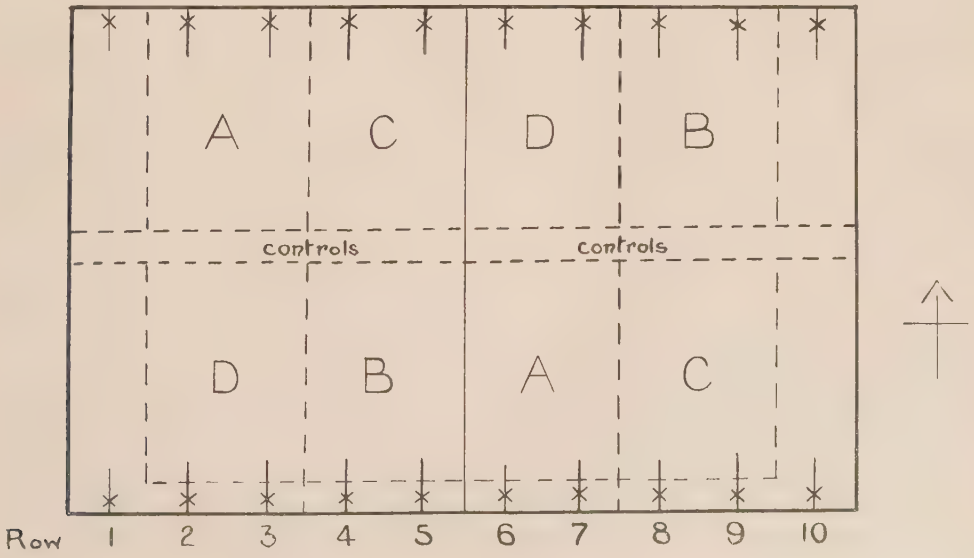
In continuation of the work done in previous years on a plot of Cox's Orange Pippin trees (6, 7), combined sprays were again applied (by a member of the ordinary farm spraying team) according to modern standards of spraying. The experiment was designed to show (*a*) whether the inclusion of a spreader increased the efficacy of the sprays used, (*b*) whether, in 1935, two pre-blossom lime-sulphur-lead arsenate sprays gave better Scab-control than one, (*c*) whether petroleum oil emulsified with sulphite lye (1, 2) could profitably be used in combination with lime-sulphur *pre-blossom* for control of Capsid and Red Spider and *post-blossom* as a spreader and sticker.

Unfortunately, a disastrous frost, which occurred during the night of 16th-17th May, ruined the crop, and thus to some extent prejudiced the results.

Description of Experiment.

A description of the arrangement of the trees on this plot of fifteen-year-old Cox's on different rootstocks has already been published (3, 5, 7), so it will not be given again here. There are 158 bush Cox trees, and the plot was divided from North to South into duplicate halves, each being further divided into four sub-plots. The treatments A, B, C and D were distributed so that each occurred once in each half and included trees on every rootstock. The headland trees on the East, South and West sides were regarded as buffers, although they received the spray treatment given to the particular sub-plot to which they belonged. On the North side there were no headland trees as another planted area was adjacent. The ninth tree of sixteen in each row (from South to North) was left unsprayed as a control ; in each row this tree was on a different rootstock.

The arrangement is shown diagrammatically below :



As in 1934, each of the sub-plots received a standard fungicide (lime-sulphur) with insecticides (nicotine and lead arsenate). In detail the treatments were :

Period.	Treatment.			
	A.	B.	C.	D.
Green-bud				LS.A. oil.
Pink-bud	LS.A.Leth.	LS.A.	LS.A. oil.	LS.A. oil.
Petal-fall	LS.Leth.N.	LS.N.	LS. oil. N.	LS. oil. N.
Three weeks after petal-fall	LS. Leth.	LS.	LS. oil.	LS. oil.

LS. *Lime-sulphur solution* of specific gravity 1·3, and containing approximately 20% (by weight) sulphur as polysulphides : **2·5% pre-blossom, 1·0% post-blossom.**

A. *Lead arsenate paste* containing 15—16% (by weight) arsenic pentoxide : **0·4%, pre-blossom.**

N. *Nicotine* of purity 95-98% : **0·05%, at petal-fall** (for Sawfly).

Leth. *" Lethalate " Standard Wetting Preparation* containing 75% commercial sodium lauryl sulphate, 20% alkali salts of di-isopropyl naphthalene sulphonic acids and 5% natural gum : **0·025% at pink-bud and " three weeks ", 0·05% at petal-fall.**

Oil. *Emulsion of a refined petroleum oil with sulphite lye :* **7·5% at green-bud, 4·5% at pink-bud, 1·5% post-blossom.** For details of the specification of the oil, see (2), page 120. The emulsified oil was sent from Long Ashton Research Station ready for use.

In all cases the various ingredients were added to the water in the order shown in the table above.

Application of Sprays.

This followed the method normally adopted for routine spraying on the Research Station farm, but a 2½ h.p. portable outfit was used, working at 200-50 lb. pressure per sq. in. To avoid variation due to the personal factor, only one man sprayed, using a 4 ft. lance and double nozzle fitted with No. 0 discs.

Green-bud spray. Applied on 15th April, treatment D only. The trees were almost at an ideal stage, although they had developed but slowly during recent bleak weather, and conditions for spraying were fairly good—dull, not too cold and with a moderate S.S.W. breeze. About 2 gallons of spray per tree were used and very good cover was obtained.

Pink-bud spray. Applied on 1st and 2nd May in bright, fairly warm weather with a light easterly breeze. Scab was already apparent on the rosette leaves of trees not sprayed at green-bud. Large canvas screens were used in this, and in subsequent sprayings to prevent spray-drift. As usual with lime-sulphur and lead arsenate, the cover was patchy, but was improved when oil-emulsion or " Lethalate " Standard Wetting Preparation (especially the former) was added. As the output from the nozzles was less than usual (a new type was being tested), the trees dripped very little, and the quantities of spray used were surprisingly low, averaging less than 2 gallons per tree.

Observations made on 7th May showed that the green-bud application had caused severe marginal leaf-burn, especially on trees on No. IX stock, while the pink-bud spray

of lime-sulphur and lead arsenate, with or without oil-emulsion, had resulted in similar but very slight damage on trees of this stock.

Further inspection on 17th May showed that most blossoms had been destroyed following the frost of the previous night (when 25° F. was registered in the screen). The sprays containing oil-emulsion had by this time induced fairly severe leaf-drop, especially on trees on stocks No. III and IX.* The flower-trusses also were badly damaged, particularly on the lower branches, the injury being equally severe whether one or two pre-blossom sprays were concerned. With sprays other than those containing oil-emulsion there was only very slight leaf-drop and marginal leaf-burn.

Petal-fall spray. Applied on 22nd and 23rd May in bright, sunny weather. A fairly strong N.E. wind made it difficult to obtain really good cover. Lime-sulphur with 1·5 per cent. oil-emulsion wetted the leaves little better than lime-sulphur alone, but with " Lethalate " it wetted very well, though not perfectly. The consumption of spray averaged nearly 2 gallons per tree.

Observations on 4th June showed that no damage was done by the petal-fall spray. The control trees bore severely-scabbed leaves, while the disease was present also on trees sprayed only once pre-blossom. Where two pre-blossom sprays were given, no Scab was seen. Oil-sprayed trees were conspicuous by their sparse foliage, especially those on the more weakly-growing rootstocks (No. I, III, IX).

" Three-weeks " spray. This, the second post-blossom application, was delayed until 14th June owing to wet, windy weather. The spraying was begun in bright, sunny weather but the sky became overcast later, and a fairly strong South wind blew. Lime-sulphur alone, or with oil-emulsion, wetted indifferently; with " Lethalate " some improvement was shown. Approximately 2 gallons of spray per tree were used. It was originally intended to include lead arsenate paste in certain of these sprays at this period, to test its efficacy for Codlin-control. As, however, the crop had been ruined by frost, this trial was not proceeded with.

Biological Observations and Weather Conditions.

Scab. From the dates when the first visible, primary infections were noted in the field, and when some ripe ascospores were found—9th April—in the dead, scabbed leaves of 1934 (kept under field conditions), it is reasonable to conclude that a period of primary infection occurred about the second week of April, when the Cox trees in these experiments were nearly at the green-bud stage. The rainfall records† show that there was steady precipitation from 2nd to 9th April, amounting to 1·54 in. This was the first wet period since the beginning of March, and it would seem to have favoured the late stages of perithecial development, and the liberation of the earliest ripe ascospores. These were plentiful towards the end of the month. Precipitation of 0·2 in. or more occurred on the 15th April (0·33 in.), the 25th (0·20 in.), and the 30th (0·48 in.). The total rainfall for April was high (3·31 in.).

* To ascertain whether this injury was due to the presence of lead arsenate with the lime-sulphur-oil-emulsion spray, certain branches of Cox trees elsewhere were sprayed (on 17th May) with one of the following: (*a*) lime-sulphur (2·5%); (*b*) as (*a*) with oil-emulsion (4·5%); (*c*) as (*b*) with lead arsenate paste (0·4%); (*d*) lime-sulphur (2·5%) with oil-emulsion (1·0%); (*e*) as (*d*) with lead arsenate paste (0·4%). Observations made on 4th June showed that: (*a*) caused slight injury; (*d*) and (*e*) rather more than (*a*); (*b*) and (*c*) very severe injury (defoliation and marginal leaf-burn, together with an uncommon form of damage, the splitting of the new shoots). Evidently the inclusion of lead arsenate was not responsible for the spray-damage.

† The writers are indebted to Mr. H. C. Chapelow for these figures.

After April, generally dry weather was experienced until mid-August.

May	..	1·82 in. (0·24 in. on 14th, 0·47 in. on 19th, 0·74 in. on 24th).
June	..	1·63 in. (0·67 in. on 4th to 6th, 0·21 in. on 17th).
July	..	1·94 in. (0·39 in. on 18th, 0·41 in. on 20th).
August	..	2·67 in. (0·31 in. on 12th, 1·14 in. on 22nd to 26th, 1·11 in. on 29th to 30th).

September, with 3·57 in., was a wet month.

Post-blossom spraying, coupled with prolonged dry periods in May, June and July, checked the development of Scab already flourishing in early May, and the disease never reached epidemic intensity.

Sawfly. No data were obtained because the blossoms were killed by frost.

Spray-injury. Estimations* of the degree of injury were made on 18th and 24th June, each tree being graded by inspection according to the sparseness of its foliage and the amount of leaf-burn. While all trees sprayed pre-blossom with lime-sulphur + lead arsenate + oil-emulsion suffered considerable injury, those on stocks No. I, III, IV and IX were most affected. The manifestation of injury was delayed in comparison with that which sometimes follows the use of lime-sulphur alone or with lead arsenate ; more than three weeks elapsed between the spray-application at green-bud and the occurrence of defoliation, although the leaves showed curled, burnt margins and turned rather yellow several days before they began to fall. Evidently, damage by oil-containing sprays may not become apparent in the first few days after application : in this, petroleum oil resembles Bordeaux mixture.

Methods Used to Obtain Results.

As the crop was very small, Scab-estimations were made on the leaves. Approximately five hundred leaves were picked at random from each tree towards the end of July. They were taken from all types of growth on all parts of the tree, and were graded† into two groups, Scab-infected and Scab-free. The number of scabbed leaves was expressed for each tree as a percentage of the total number examined.

In mid-September, the few fruits that reached maturity were picked and aggregated according to treatment but regardless of rootstock, and graded for Scab by the " category " method (3, 4). No record was made of attack by Capsid, Sawfly, Winter Moth or Codlin Moth, for this was negligible.

The distribution of Red Spider was determined periodically by general inspection.

Results.

In the larger table herewith, the results from the two halves of the plot have been kept separate, for they are dissimilar. Trees on the East half have always been rather larger and more prone to Scab than those on the West. This may be due to soil differences. As regards rootstocks, one half-plot is the complement of the other for any one spray-treatment.

* The writers are indebted to Miss A. B. Beakbane and Miss M. E. Renwick for making this survey.

† The writers are indebted to Miss M. E. King for help with this work.

Tabulated Data.

Variety—Cox's Orange Pippin.

Treatment.	West half of plot. Stocks included.	No. of trees.	Fruit. Number.	Fruit. Scab-Equivalent.	Leaves. % Scab.	East half of plot. Stocks included.	No. of trees.	Fruit. Number.	Fruit. Scab-Equivalent.	Leaves. % Scab.
A. LS.A.Leth. .. / ——— * / LS.Leth.N. .. / LS.Leth. ..	I, II, V, X.	27	71	3·5	10·6	III, IX, XIII, XVI.	28	100	6·5	12·4
B. LS.A. .. .. / ——— / LS.N. .. .. / LS.	III, IX, XIII, XVI.	28	61	1·6	5·7	I, II, V, X.	28	174	5·0	11·6
C. LS.A. oil .. / ——— / LS. oil N. .. / LS. oil	III, IX, XIII, XVI.	28	61	0·6	4·8	I, II, V, X.	28	93	9·0	16·6
D. LS.A. oil .. / LS.A. oil .. / ——— / LS. oil N. .. / LS. oil	I, II, V, X.	28	73	1·9	3·4	III, IX, XIII, XVI.	28	122	1·7	7·2
Unsprayed control .. (West and East halves together).	I, II, V, X, III, IX, XIII, XVI.	8	25	24·5	37·2					

* The short, horizontal line indicates the blossom period.

Summary of Data Concerning Leaf-Infection by Scab.

Variety—Cox's Orange Pippin (both halves of plot).

Treatment.	Rootstock. I.	II.	III.	V.	IX.	X.	XIII.	XVI.	Total.	Average.
A.	10·5	10·5	12·1	13·6	11·6	8·1	9·1	17·3	92·8	12
B.	10·1	10·9	5·4	16·4	5·8	7·7	5·6	5·9	67·8	9
C.	12·4	16·2	3·9	13·2	4·9	25·9	5·6	4·4	86·5	11
D.	4·4	2·4	6·8	4·5	10·1	2·5	6·7	4·2	41·6	5
Control (one tree on each stock).	42·8	18·6	44·2	50·6	22·0	47·6	36·2	35·3	297·3	37
Total ..	80·2	58·6	72·4	98·3	54·4	91·8	63·2	67·1		
Total number of trees on each stock	15	15	15	15	15	14	15	15		

Discussion of Results.

The Crop. There is no evidence that the small crop left by the frost was further reduced by any of the spray-treatments.

Scab (*Venturia inaequalis* Cooke (Wint.)). Two pre-blossom sprays were again more beneficial than one, as in 1934. It will be recalled that Scab-infections were seen on the rosette leaves before the flowers opened. The degree of infection on leaves and fruits was considerably reduced on all sprayed trees in comparison with unsprayed controls, which showed severe infection. The addition of " Lethalate " or of oil-emulsion appears to have made little, if any, difference to the effectiveness of lime-sulphur. In 1934 (7) little difference in this respect was shown *between* three spreaders tested, though no comparison was made with lime-sulphur without a spreader.

Close correlation is shown by results on leaves and on fruit. Trees on stock No. II, controls especially, were more severely affected by drought than those on other stocks and considerable defoliation resulted. The most badly scabbed leaves dropped before this survey was made, and control trees on No. II thus received a relatively low figure for leaf-infection. Trees on stocks No. V, X, I or III showed more heavily infected leaves than those on No. IX, II, XIII or XVI.

Red Spider (*Oligonychus ulmi* Koch). A detailed inspection of leaves was made with a hand-lens on 28th June. Spider was rarely found on sprayed trees, whatever the treatment, while control trees were very severely infested, numerous summer eggs being found on all the mature leaves examined, though adults were less frequent. It was intended to make a thorough survey of the whole plot later, but on 8th August few spiders or eggs were found, *even on control trees*. These had suffered severe defoliation caused by drought, coupled with Scab and Red Spider ; probably most of the infestation that had existed on the trees earlier disappeared when the leaves dropped.

Thus no evidence was forthcoming regarding a possible increase in acaricidal effect from adding oil-emulsion to lime-sulphur, but there were signs at the end of June that all spray-treatments had given excellent control.

Summary.

The results of this trial on Cox's Orange Pippin were considerably prejudiced by a severe frost in May, which ruined the crop ; nevertheless, the following were obtained :

(*a*) Better control of Scab was given by two pre-blossom sprays (coupled with post-blossom applications) of lime-sulphur, with lead arsenate and petroleum-oil emulsion, than by one. The applications were made at green-bud and pink-bud, and each caused severe leaf-burn and defoliation.

(*b*) Three applications, at pink-bud, petal-fall and three weeks after, of lime-sulphur with certain addenda gave good control of Scab and Red Spider, unsprayed control trees being severely attacked. The severity of attack by Scab was assessed on leaves and fruit, and by Red Spider on leaves. The influence of rootstock was shown by Scab on the leaves.

(*c*) No consistent evidence was forthcoming that the addition of oil-emulsion or of " Lethalate " Standard Wetting Preparation to lime-sulphur affected fungicidal or acaricidal efficiency.

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FIELD TRIALS IN 1935 OF THE FUNGICIDAL AND PHYTOCIDAL PROPERTIES OF CERTAIN NEW CHEMICAL PREPARATIONS

A PROGRESS REPORT

By H. B. S. MONTGOMERY, M. H. MOORE and H. SHAW

Introductory.

Preliminary work was done in 1934 to determine whether certain new preparations possessed any advantages over the well-known fungicides, Bordeaux mixture and lime-sulphur, for the control of Apple Scab (*Venturia inaequalis*).

A fairly elaborate system of testing on a small scale was evolved. Trials were designed so that each one of a series of eighteen-year-old Cox's Orange Pippin trees on No. II stock included a complete experiment. Ten healthy branches of each tree were selected for spraying, and each experiment was arranged thus:

Bordeaux mixture (0·6% copper sulphate, 1·2% hydrated lime)	2 branches.
Lime-sulphur solution* (1·0% by volume)	2 ,,
Test spray, dilution (1)	2 ,,
Test spray, dilution (2)	2 ,,
Control (unsprayed)	2 ,,

Each tree had already received, at pink-bud, lime-sulphur (2·5%) with lead arsenate paste (0·3%) as a routine spray.

The two branches for each treatment were chosen at random so that any variation due to position on the tree was distributed. Sprays were applied by knapsack on (1) 29th and 30th May (about a week after petal-fall) and (2) 19th and 20th June. Branches other than the two being sprayed were protected from drift by covering them with muslin sheets.

The dry season proved unfavourable for Scab, and infection did not develop very freely. The fruit was graded for Scab and russeting, and spray-damage to the leaves was assessed by periodic inspection. Bordeaux mixture proved the best fungicide, but it caused severe fruit-russeting and leaf-burn. Lime-sulphur also gave good results against Scab, with little damage.

From seven single-tree experiments, three of the new preparations were selected for extended trial in 1935; two, a mercurated chlorophenol and a salicylanilide-Methic Green preparation, were abandoned as being unsuitable, and the two others, cuprous cyanide and the product of the reaction between sodium salicylanilide and copper sulphate, were retained for further phytocide tests.

Hence, the work in 1935 was divided into two sections, (1) an extended trial of the three preparations already mentioned, (2) single-branch phytocide tests of further new preparations.

(1) Extended Trial.

A plot of 122 eight-year-old bush apple trees of the varieties Worcester Pearmain (31 trees), Edward VII (30 trees), Allington Pippin (31 trees) and Newton Wonder (30 trees), all on No. IX layered rootstock, and planted according to a statistically-randomized plan, was reserved for these tests.

* Of specific gravity 1·30, and containing approximately 20% polysulphide sulphur by weight.

The three preparations tested (against Scab) were:

I. A 25% dispersion of Shirlan (salicylanilide) at 1·0% and 0·5% (by weight).

II. A dispersion containing 22·7% Shirlan and 1·6% Methic Green at 1·0% and 0·5% (by weight).

III. A 15% dispersion of tetramethylthiuram sulphide at 1·0% and 0·5% (by weight).

These, each of which contained Agral N and a peptized glue as spreader, were compared with the standard sprays, Bordeaux mixture (0·5% copper sulphate, 1·5% hydrated lime) and lime-sulphur solution (at 2·5% pre-blossom and 1·0% post-blossom, by volume), each without a spreader, as controls.

Four applications of spray were made at (1) green-bud (17th April); (2) pink-bud (3rd May); (3) petal-fall (29th May); (4) about three weeks after (3) (21st June). A hand-pumped barrel-machine was used, developing 200-50 lb. per sq. in. pressure, and large canvas screens, specially made for the work, were manipulated into positions to arrest spray-drift. On each occasion the trees were heavily sprayed, thus ensuring complete initial cover of leaves and other parts susceptible to Scab-infection. All the new preparations wetted the leaves well.

Unfortunately, severe frost occurred on the night of 16th-17th May when most of the trees were still in flower. This resulted in the almost total destruction of the crop on all trees except some of the Edward VII (which flowers very late). Scab-estimations on the leaves were made, however, on (*a*) 15th July and (*b*) 6th September, with the results shown in the accompanying table of figures.

Summary of Scab-estimations on Leaves, 1935.

		E.M.R.S. Ref. No.	Worcester Pearmain.	Edward VII.	Allington Pippin.	Newton Wonder.	Av. for treatment.
Test-spray I. (1·0%)	(a)	3563	0·00	0·00	2·75	1·50	1·06
	(b)		0·00	0·00	2·75	1·50	1·06
Test-spray I. (0·5%)	(a)		0·00	0·00	3·50	2·00	1·38
	(b)		0·00	0·00	3·25	1·25	1·13
Test-spray II. (1·0%)	(a)	3545	1·50	0·00	2·50	1·50	1·38
	(b)		0·50	0·00	2·50	1·00	1·00
Test-spray II. (0·5%)	(a)		0·50	0·00	3·50	1·50	1·38
	(b)		0·00	0·00	3·75	2·00	1·44
Test-spray III. (1·0%)	(a)	3540	0·00	0·00	2·00	1·25	0·81
	(b)		0·00	0·00	2·25	0·75	0·75
Test-spray III. (0·5%)	(a)		0·00	0·00	3·00	1·00	1·00
	(b)		0·00	0·00	3·75	1·50	1·31
Bordeaux Mixture (0·5% copper sulphate, 1·5% hydrated lime)	(a)		0·00	0·00	0·00	0·00	0·00
	(b)		0·00	0·00	0·00	0·00	0·00
Lime-sulphur (2·5%, 1·0%)	(a)		0·00	0·00	0·25	0·50	0·19
	(b)		0·00	0·00	0·50	0·00	0·13

The estimations were made by inspection, each tree in turn being graded into one of five categories of Scab ranging from 1 (very slight) to 5 (very severe), while trees entirely free from Scab were registered as 0. The figures represent the average from four similarly-sprayed trees of each variety, except with Bordeaux mixture. Here, three trees each of Allington and Worcester and two trees each of Edward VII and Newton were sprayed.

Scab was prevalent on Allington, and, to a less extent, on Newton during 1935, but it developed little on Worcester and (as is usual in this district) not at all on Edward VII. Worcester and Edward VII, therefore, cannot be regarded as good indicator varieties in the current season.

Bordeaux mixture kept the trees free from Scab throughout the season, while lime-sulphur was only slightly less effective ; the three new preparations were definitely inferior. None of the sprays caused damage of any consequence. Slight marginal leaf-burn was noted on lime-sulphur-sprayed trees following the pre-blossom application, and slight leaf-drop occurred at the end of June on Bordeaux-sprayed Allingtons.

The light crop of fruit was graded for Scab, but the results are not reliable because the units were too small, and cropping too variable. The few data obtained supported the results given by the leaves.

An estimation of Red Spider on the leaves was made on 4th July, in collaboration with Mr. W. Steer. The tetramethylthiuram sulphide dispersion at 1·0% showed distinct promise against this pest.

General Remarks and Conclusions.

The three new preparations, even at 1·0%, proved unsatisfactory against Apple Scab, and thus compared unfavourably with the standard fungicides, lime-sulphur and Bordeaux mixture. It does not seem profitable to include them in further trials against Scab.

(2) Preliminary Phytocide Tests.

Several new preparations, hitherto not tested at this Station, or tested and found unsatisfactory at certain concentrations, were sprayed just after petal-fall (30th May or 3rd June) on to single branches, or parts of branches, of established Cox's Orange Pippin trees. A low-pressure, hand-operated solo sprayer was used for application. Light hessian was thrown over adjoining branches to protect them from spray-drift.

Spray-damage was assessed by periodic inspection of the sprayed branches ; the results are appended below. Observations were made incidentally on the presence or absence of Scab on the sprayed leaves, and any effect of the sprays on existing Scab lesions was noted. These, however, are not treated as records of primary importance ; they were taken to give some general indication of the potentialities of the preparations as fungicides.

General Remarks and Conclusions.

A. Of the preparations which were safe at the strengths tested :

(*a*) Malachite Green, Brilliant Green, Methic Green and Auramine OS are water-soluble and would thus be washed from the trees in wet weather. This militates against their use as protective fungicides.

(*b*) The 40% dispersed sulphur at 1·0% showed some promise against Scab, but at 0·5% it was not so satisfactory.

Product.	E.M.R.S. Ref. No.	Concentration (by weight).	Remarks.
(1) Malachite Green AS ..	3541	0·1%	Poor wetting ; no damage.
(2) Brilliant Green YS ..	3542	0·1%	Wetting slightly better than (1) ; generally safe.
(3) Auramine OS	3544	0·1%	Very poor wetting ; no damage.
(4) Methic Green	3543	0·1%	Slightly better wetting than (1) ; no damage.
(5) Burgundy paste ..	3546	1–15 (0·6% Cu)	Good suspension readily formed ; poor wetting ; severe damage (leaf-drop, burning and curling).
(6) do.	do.	1–30 (0·3% Cu)	As (5), but damage rather less severe.
(7) Cuprous oxide-Goulac paste	3547	1–28 (0·6% Cu)	Poor wetting ; severe damage (leaf-drop, burning and curling).
(8) do.	do.	1–56 (0·3% Cu)	As (7), but damage rather less severe.
(9) Cupric oxide-Goulac powder	3548	1–101 (0·6% Cu)	Very poor wetting ; severe damage (leaf-drop, burning).
(10) do.	do.	1–202 (0·3% Cu)	As (9), but damage rather less severe.
(11) Zinc-" Bordeaux " ..	3549	0·8% zinc sulphate, 1·2% hydrated lime. (0·18% Zn)	Precipitate not as voluminous, suspension not as stable, and wetting scarcely as good as with copper Bordeaux ; lasting deposit ; no damage.
(12) 40% Dispersed sulphur	3564	1·0%	Good suspension, readily formed ; wetting good ; no damage.
(13) do.	do.	0·5%	As (12).
(14) 25% Dispersed 8-hydroxyquinoline	3570	1·0%	As (12).
(15) do.	do.	0·5%	As (12).
(16) 10% 1-Chloro-2-naphthol-dekalin emulsion	3568	2·0%	Not easy to spray ; moderate wetting ; extremely severe damage within twelve hours. This was followed by complete defoliation and splitting of young shoots, and the one fruitlet present on the branch became severely russeted and cracked.
(17) Dekalin emulsion (control for 3568)	3569	2·0%	Wetting inferior to that of (16) ; no damage.
(18) 10% 1-Chloro-2-naphthol-miscible oil ..	3565	2·0%	Wetting fairly good ; very slight damage—curling and burning of young leaves ; probably a borderline case.
(19) Agral AX–Agral SRT (miscible oil—control for 3565)	3566	2·0%	Wetting rather less satisfactory than with (18) ; no damage.

Product.	E.M.R.S. Ref. No.	Concentration (by weight).	Remarks.
(20) Reaction product of sodium salicylanilide and copper sulphate ..	3410	1·0%	Suspension good; wetting good; not safe—severe bronzing, spotting and some leaf-drop.
(21) do.	do.	0·5%	Similar behaviour to that of (20); apparently a borderline case—only very slight leaf-spotting and no obvious defoliation.
(22) Cuprous cyanide paste ..	3429	0·3%	Wetting moderate; not safe; considerable leaf-burn and defoliation.
(23) do.	do.	0·2%	As (22) but damage rather less severe.
The following were applied on 8th August :			
(24) Goulac (control for 3576 and 3577) ..	3554	0·45%	Some difficulty in dissolving in cold water; wetting very good; no damage.
(25) Zinc-lime-Goulac paste ..	3577	5·0% (approx. 0·3% Zn)	Suspension fairly readily formed; wetting very good; persistent deposit; no damage.
(26) Zinc hydroxide-Goulac paste	3576	1·25% (approx. 0·3% Zn)	Ready suspension; very good wetting; produced an unusual form of spray-damage, the foliage being flushed reddish-bronze tending to yellow on some leaves; no defoliation; of doubtful safety.
		(by volume)	
(27) Petroleum oil emulsified with sulphite lye* ..		7·5% (5·0% oil)	Suspension readily formed; good wetting; very severe defoliation.
(28) do.		4·5% (3·0% oil)	As (27), but damage rather less severe.
(29) do.		1·5% (1·0% oil)	Suspension readily formed; moderate wetting; no damage.

(*c*) The 25% dispersed 8-hydroxyquinoline at 0·5% allowed Scab to grow freely on the leaves. On leaves sprayed with a 1·0% preparation, rather less Scab developed.

(*d*) The dekalin emulsion and the Agral AX-Agral SRT were controls for the 10% 1-chloro-2-naphthol-dekalin emulsion and the 10% 1-chloro-2-naphthol-miscible oil respectively. They contained no fungicides. This applies also to Goulac, which was a control for the zinc-lime-Goulac paste and for the zinc-hydroxide-Goulac paste.

(*e*) The zinc-" Bordeaux " and the zinc-lime-Goulac paste showed some initial promise, for both gave a very persistent deposit.

(*f*) Petroleum-oil-sulphite-lye emulsion, at 1·5%, was being tested as a possible addendum to lime-sulphur to improve its spreading and sticking properties (see this report, pp. 191-7).

* As used at Long Ashton (see Kearns, Marsh and Pearce in the Annual Report of Long Ashton Research Station for 1932, pp. 66-85, and Kearns, Marsh and Martin, Annual Report for 1934, pp. 109-25) and in one trial at East Malling (see this report, pp. 191-7).

B. Among the preparations which caused no serious damage were the reaction product of sodium salicylanilide and copper sulphate, at 0·5%, the 10% 1-chloro-2-naphthol-miscible oil at 2·0% and the zinc-hydroxide-Goulac paste at 1·25%. There was no evidence of their effect on Apple Scab.

C. The following preparations proved unsafe to use on Cox's Orange Pippin : the Burgundy paste at 1-15 and 1-30, the cuprous oxide paste at 1-28 and 1-56, the cupric oxide at 1-101 and 1-202 (these will now be subjected to further test at lower concentrations, equivalent to 0·2% and 0·1% copper as contained in Bordeaux mixtures of 0·8% and of 0·4% copper sulphate), the 10% 1-chloro-2-naphthol-dekalin emulsion at 2·0%, the reaction product of sodium salicylanilide and copper sulphate, at 1·0%, the cuprous cyanide at 0·3% and 0·2% and the petroleum-oil-sulphite-lye emulsion at 7·5% and 4·5% (tested with a view to its addition to lime-sulphur in spring, to give a combined spray against Capsid, Red Spider and Scab (see this report, pp. 191-7).

Summary.

Tests of the fungicidal and phytocidal properties of certain new chemical preparations are described. Of the preparations which showed promise in 1934, none proved as effective as Bordeaux mixture or lime-sulphur against Scab in an extended field trial in 1935.

Acknowledgment.

The writers are indebted to Messrs. Imperial Chemical Industries Ltd. for a grant in support of the programme of work described.

Section IV

BULLETINS FOR FRUITGROWERS

POMOLOGY

THE RAPID CONVERSION OF UNPROFITABLE FRUIT TREES BY GRAFTING*

By R. J. GARNER

Under certain conditions fruitgrowers decide to top-graft their fruit trees with another variety. The normal method of top-grafting suffers from the following main disadvantages. The severe deheading results in the waste of several years while the tree grows another framework. The balance between root and shoot is upset resulting perhaps in the ill-health commonly associated with " deheading ". The large wounds caused invite the entry of pests and diseases.

These disadvantages may be partly overcome by the use of a method evolved principally in Tasmania. In this method the framework, or main limbs of the tree, is retained and either budded or grafted with scions of the more profitable variety. It is clear that in this method the amount of the old variety retained can vary. In the case of some of the largest trees on which this method has been practised as many as five hundred grafts were successfully placed on each tree of twenty to thirty years of age, branches of about one inch in diameter being grafted. The method is equally successful when applied to smaller and younger trees. The use of this method results in very little check to the growth of the tree which can return to full cropping almost immediately. For example, reports from Tasmania show that it is not uncommon for an apple tree to bear two cases of fruit during the year of grafting, and from ten to twelve cases the following season. Finally, losses due to the death of the tree are practically eliminated. These advantages have been found to outweigh the disadvantage of the extra expense in operation which the method entails. It is now proposed to discuss a name for the method.

Choosing a Name.

The Tasmanian trees to which this method was originally applied, with their rigid frameworks studded with hundreds of grafts all pointing in an upward direction, and set at similar angles with the main branches, were likened to porcupines and the method became known as " porcupine grafting ". Unfortunately, this name was also applied to other similar methods and a confusion of nomenclature has arisen. It is suggested that the term " porcupine-grafting " be reserved for the method described later under that heading, and that the term " frameworking " be applied to all methods

* Reprinted by permission from *The Berkshire Farmers' Year Book for* 1936.

of budding and grafting involving the retention and use of the complete framework of the tree. Such methods include porcupine-grafting, stub-grafting, side-grafting and framework-budding.

METHODS OF FRAMEWORKING.

(1) *Framework Budding.*

The tree to be budded is prepared in the winter by removing all small lateral branches and spurs from the main framework of the tree. If the main branches have become crowded these should be thinned out to suitable distances. The extent to which the main branches are shortened will be governed largely by the number of buds the operator intends to insert during the coming season. The terminals are either whip- or rind-grafted at the usual grafting time.

The severely pruned tree will normally produce many young shoots from dormant buds which are present near the wounds caused by the removal of spurs and lateral branches. Whilst these young shoots are still less than three inches in length they should be thinned out to one shoot for every eight to twelve inches of framework branch, and left in positions where lateral fruiting branches are desired. Generally speaking the undersides of the main branches are not suitable positions for fruiting branches, and scions are usually placed alternately on the lateral sides of the main limbs. Provided the tree is in a healthy condition the shoots mentioned will become sufficiently large and ripened by August for receiving the buds of the more profitable variety.

One bud is inserted in the base of each young shoot, as in ordinary shield-budding and as closely as possible to the main branch. It is recommended that the buds should be tied with rubber budding-strips rather than with raffia or other non-elastic material. Rubber has the advantage of being able to expand with the growing shoot and thus avoids constriction in the region of the bud. Each shoot should be cut away immediately above the bud during the latter part of February. The inserted bud normally remains dormant until April. A shoot in which the bud has died before the spring may be stub-grafted in March.

Framework-budding has the advantage of economizing in scion material, only one bud being required for each new lateral, but there are disadvantages. The first of these is that the budding must be done during August, a busy season for fruitgrowers. The second is that the buds require tying and in the light of experience at East Malling it appears that methods of grafting and budding which require tying with raffia, string or similar material, or wrapping with adhesive tape, are usually too wasteful of time to be used in practical frameworking. The third disadvantage is that a whole growing season is wasted in producing the lateral shoots required for budding. Finally, a disadvantage in the case of all varieties, except those which readily produce axillary fruit buds, is that the growth from a single bud is often of such vigour that a further season is required for the more profitable variety to return to fruiting. For these reasons one would not recommend the use of framework-budding and it is here described because it has been reported as successful both in Tasmania, and in the case mentioned below of Bramley's Seedling framework-budded with Grenadier.

(2) *Porcupine-grafting.*

The tree to be grafted is cleared of all lateral branches and spurs either during the dormant season or at grafting time. Grafting is done when the rind parts readily from the wood. In Southern England this condition is normally reached in early April.

The scion wood is cut into lengths bearing four to six buds. If short scions possessing only two buds are used there will be a reduced tendency towards early fruit-bud formation owing to the fact that these two buds usually push into vigorous wood growth. Longer pieces of scion wood frequently develop shoots from the upper one or two buds and small fruiting laterals or spurs from the lower. Each scion is prepared by a simple slanting cut measuring one and a half to two inches in length as in Diagram I (A) with a cut of a quarter of an inch in length at the base on the opposite side to the longer cut surface. An inverted L shaped cut is made in the rind of the main branch, the cut penetrating to the wood. The rind is raised at the junction of the horizontal and vertical cuts and the scion is pushed home as in Diagram I (B). The scion is held firmly in position by means of a $\frac{5}{8}$-in. gimp-pin, or other suitable small nail, driven so as to pass through the edge of the raised bark and the scion, and to pass into the wood of the branch. The terminals are either whip- or rind-grafted. The operation is completed by covering all cut surfaces with grafting wax or similar material which is,

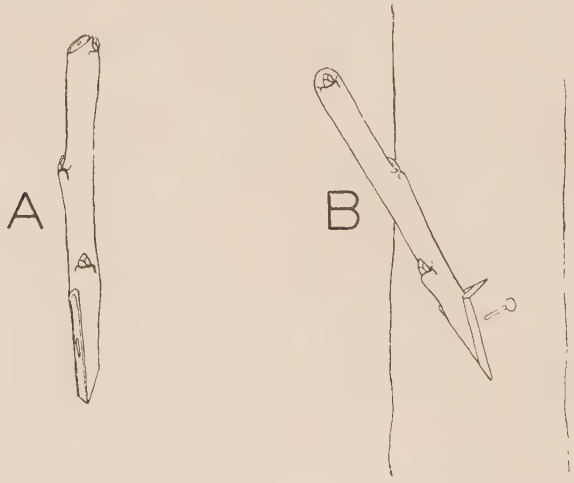

DIAGRAM I.

of course, applied to check the drying out of the cut tissues and to prevent the entry of wound-parasites.

(3) *Stub-grafting.*

The tree to be grafted is cleared of lateral growths except small lateral branches varying from $\frac{1}{4}$ in. to 1 in. in diameter which are retained wherever it is desired to have lateral branches of the new variety. This work may be carried out at any time during the dormant season prior to grafting. Scions having from four to six buds are prepared with their basal ends in the form of a wedge as shown in Diagram II (A). The lateral branch to be grafted receives a cut on its upper side commencing about half an inch from the main branch and extending to the base almost as far as the centre of the lateral shoot. This cut is opened by bending down the lateral and the prepared scion is inserted as illustrated in Diagram II (B). It is essential that at least a portion of the cambial tissue of the scion should be in contact with that of the lateral branch into which it is inserted. The lateral is released and cut off immediately above the insertion of the

scion as depicted in Diagram II (C). The terminals are either left entirely unpruned, and removed one year later at a point immediately above the uppermost stub-graft, or this removal may take place at the time of stub-grafting. Alternatively the ends of the branches may be whip- or rind-grafted as in other methods of frameworking. The covering with grafting wax of all exposed cut surfaces completes the operation.

Seeing that stub-grafting does not entail the separation of the rind from the wood, but in principle resembles a cleft-graft, the practice of this method is not restricted to the growing season. In the case of apple trees stub-grafts have been successful at East Malling when inserted during March, April, early June and mid-July and it is probably safe to say that in the South of England stub-grafts would be successful when inserted during the season February-July provided suitable dormant scion wood is available. The period March-April is probably the one in which there is the greatest chance of success.

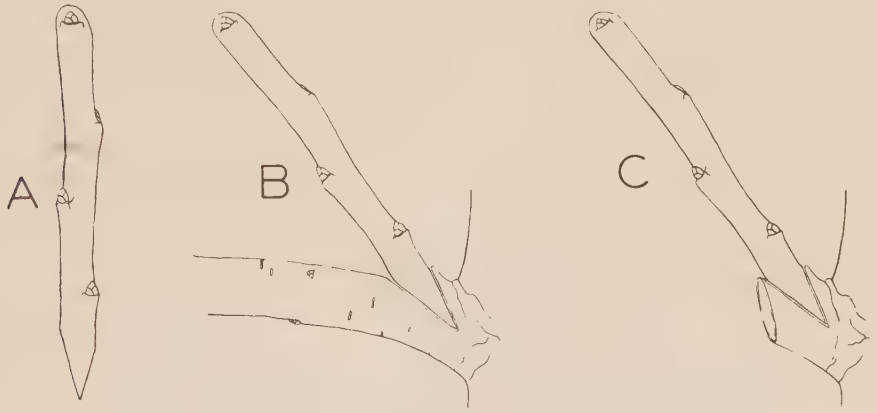

DIAGRAM II.

(4) *Side-grafting.*

Established trees of varieties of apples such as Newton Wonder often possess main branches almost completely devoid of laterals suitable for stub-grafting. Such branches having a diameter greater than 1½ in. are suitable for porcupine-grafting. The thinner branches lend themselves to side-grafting.*

The scions are prepared as for stub-grafting except that the basal wedge is made more tapering. A cut is made into the side of the branch, at an angle of about 20°, not deeper than one-third of the diameter of the branch. The cut is opened by bending the branch, and the scion is inserted with its cambium in contact with that of the framework. Releasing the branch causes the scion to be firmly held. In order to complete the graft it only remains to cover the exposed cut surfaces with grafting wax.

Aftercare of Frameworked Trees.

Once the tree is grafted or budded no further attention is required until sucker shoots arise from the main branches of the old variety. These shoots should be rubbed out while still soft and green. It is rarely necessary to go over the trees for the removal

* The writer is indebted to Mr. W. Fowle of Kirdford, Sussex, for suggesting the employment of side-grafting in frameworking.

of shoots more than twice in the first season. Thereafter any shoots which arise from the old variety may be dealt with at the time of the annual pruning.

Trials of Frameworking Methods at East Malling.

These were inaugurated in 1932 on lines suggested by Mr. R. G. Hatton, Director of the Research Station. During a world tour undertaken in 1930-1, Mr. Hatton had the opportunity of studying frameworked trees in Tasmania and thought such methods might be found useful under certain conditions in this country.

(1) *Apples.*

The first trial carried out in 1932 was one of framework-budding. The established scion variety was Stirling Castle upon which it was desired to bud Worcester Pearmain so as to provide as rapidly as possible a suitable pollenating variety in a plantation of Cox's Orange Pippin. In this case the method failed, perhaps because the weak growing Stirling Castle bore poorly ripened young shoots upon which the buds could take only with difficulty.

In April, 1933, eight twelve-year-old bush trees of Stirling Castle, worked upon rootstock No. XVI, were frameworked with Worcester Pearmain by means of whip-grafting and porcupine-grafting. An average of nearly two hundred grafts were placed on each of the eight trees and were about 90 per cent. successful. During the summer of 1933 up to a maximum of six fruits per tree were carried on the actual scions inserted in April; doubtless these fruits were developed from fruit buds present on the scion wood before it was removed from the parent tree. In 1934 fruits numbering 223 and weighing in all 60 lb. were produced by the eight frameworked trees. By the end of 1934 the trees appeared to be fully furnished with fruiting wood and promised well for 1935. Unfortunately for this trial the severe frost in May, 1935, destroyed the crop.

A further trial was laid down in the spring of 1934 in which twelve twenty-year-old bush trees of Bramley's Seedling on the rootstock No. II were porcupine-grafted with Grenadier. Each tree received about eighty grafts. Twelve similar trees were successfully framework-budded during the same season. Eight trees of Stirling Castle similar to those worked in 1933 were also successfully stub-grafted with Worcester Pearmain in the spring of 1934.

In April, 1935, twenty thirteen-year-old standard trees of Newton Wonder worked upon various vigorous rootstocks, were stub-grafted with Laxton's Superb. More than 95 per cent. of these scions made excellent growth. A further batch of thirty-two bush trees of Stirling Castle was successfully stub-grafted with Worcester Pearmain during the same season.

(2) *Plums.*

Two eight-year-old standard trees of Laxton's Utility plum growing at East Malling were successfully frameworked by means of whip-grafting in the spring of 1933. Each tree received approximately one hundred grafts, the scion varieties being Victoria and Czar respectively. Practically every graft grew and in 1934, the year following that in which the trees were grafted, the Victoria tree bore 60 lb. and the Czar 80 lb. of fruit. In 1935 when even heavier crops were expected, the trees failed to crop owing to severe damage by late spring frosts.

A thirteen-year-old tree of Newton Wonder stub-grafted with Laxton's Superb.

Discussion.

The simplicity of stub-grafting makes it the ideal method of frameworking for trees possessing suitable lateral shoots. Large branches devoid of laterals lend themselves best to porcupine-grafting, while small bare branches are most suitable for side-grafting. It will be noticed that the whole tree may be frameworked without the use of any tying material whatsoever.

Owing to the relatively large number of operations in frameworking as compared with those in top-grafting, the labour costs of the former tend to be high but may be reduced by the use of quick methods easily learnt by the average farm-worker. Long apprenticeship to a skilled grafter is unnecessary.

It is difficult to estimate the cost of frameworking because it is likely to vary widely from one district to another. It has been the writer's privilege to inspect the costings of one grower who inserted 25,000 stub- and side-grafts into 372 trees of seven years of age. By using the entire staff of the farm the costs were kept as low as 1s. 10d. per hundred grafts. This figure includes the cost of preparing the trees, clearing up and buying $1\frac{1}{4}$ cwt. of wax. The scion wood was collected on the farm from amongst the prunings and was not included in the costings. These grafts were between 95 per cent. and 100 per cent. successful.

The writer wishes to acknowledge the help of Mr. D. H. Hammond in connection with the practical aspect of the work and also the assistance of Mr. C. E. Cornford in the preparation of this article.

Summary.

It is shown that the chief disadvantages to the normal method of top-grafting may be overcome by the use of another method in which the framework of the tree is retained and either budded or grafted.

The terms " frameworking " and " porcupine-grafting " are discussed.

The four frameworking methods, framework-budding, porcupine-grafting, stub-grafting and side-grafting are described in detail and discussed.

The aftercare of frameworked trees is described.

An account is given of trials of frameworking methods, carried out at East Malling on apples and plums.

Certain methods of frameworking are advocated and the cost of frameworking is compared with that of top-grafting. One example is given of the cost of frameworking as practised on a fruit farm.

SOME OBSERVATIONS ON THE ROOTS OF FRUIT TREES*

By W. S. ROGERS

One side of the study of the soil which has not received much attention but which nevertheless forms a most important link between the scientist and the grower, is the relation between the soil and root growth of plants. To the plant the soil is not a mere collection of mineral particles, but the root environment—the storehouse of food and water from which it must draw all the matter of which it is composed, except the carbon. The reaction of the root to the soil in which it finds itself therefore largely controls the plant performance.

At East Malling Research Station we have been studying the root-systems of fruit plants for a number of years. We have carried out these studies by various methods, such as the excavation of the whole root-systems of fruit trees (2-5), the observation of growing roots in special root observation boxes and underground root observation trenches in the orchard (6), and by observing the performance of known fruit varieties grafted on to different rootstocks (1). The results given are therefore all drawn from actual field experiments, made with very carefully recorded material.

Root Excavations.

In the most comprehensive series of excavations the complete root-systems of twenty-six Lane's Prince Albert apple trees, ten and eleven years old, on various clonal rootstocks, were excavated from three soils, loam, light sand and heavy clay (5). The trees had been planted as experimental plots, and form a unique and truly comparable series. The soils were chosen for their contrast. The sand was a very deep sandy soil at Wisley, Surrey, containing in the subsoil, about 98% coarse and fine sand and 2% silt and clay. The loam at East Malling contained 55% coarse and fine sand, and 21% fine silt and clay ; the clay, at Wisborough Green, Sussex, 8% coarse and fine sand and 82% silt and clay.

Extent of Root-system. One of the most striking points is the remarkable extent of the root-systems (5). In all cases the roots spread farther than the branches. In the sand the root spread was two to three times the branch spread. In the loam and clay it was about 1·6 times the branch spread. The size of the tree varied according to the soil—the sand producing very small trees, the clay medium trees and the loam large trees. Plate I shows the reconstructed root-system of a ten-year-old apple tree on rootstock Malling No. II on the poor sand, and Plate II a sister tree on the heavy clay. The greater vigour but relatively more constricted root-system in the latter case is clearly seen. Different rootstocks produce trees covering a wide range of vigour on all soils ; it is therefore desirable to use standardized rootstocks chosen to suit the soil (1).

Root Depth. The three soils showed sharp contrasts in root depth, illustrating various limiting factors. On the sand there was a shallow scaffolding of main roots with

* Reprinted by permission and with some alterations from *Transactions of the Third International Congress of Soil Science*, Vol. I, 1935, pp. 249-53.

vertical roots descending to various depths (Plate I), the maximum was 190 cm.* on the most vigorous stocks.

On the loam there was a similar shallow scaffolding, but numerous vertical roots descended to the Ragstone rock which underlies this soil at a depth varying from 100 to 300 cm. The roots often turned horizontally along the rock and ramified profusely in the sticky "accumulation layer" just above it. The deepest roots found reached 296 cm. These were from a tree on a very dwarfing rootstock, proving conclusively that dwarf trees are not necessarily shallow rooted. On the clay (Plate II) the main roots sloped down and grew along in the sticky subsoil between 30 to 60 cm. deep. Branch roots grew upwards and downwards. There was a very sharply marked depth boundary at about 90 cm., though a few young roots had penetrated to 118 cm. Roots that had grown deeper than 90 cm. in previous years had been killed back to the 90 cm. level. This suggests a seasonal water table cutting off aeration.

The Feeding Roots. The fine fibrous root, which was taken as a rough measure of the feeding roots, was found to grow everywhere and in all directions. It was fairly evenly distributed over the whole root-system. Only about 10 per cent. of the fibre was in the square metre surrounding the trunk of ten and eleven-year-old trees on loam. Nearly half the fibre was outside the 3 metre square surrounding the trunk. Hence, for most efficient feeding manure should be spread over the whole root area, reaching well beyond the branch spread. About half the fibrous root was more than 50 cm. below the soil surface. The deep position of so much root probably explains why manures take so long to show an effect on some fruit trees.

Amount of Root. The trees varied greatly in size and in the amount of fruit they had borne, according to the stock on which they were worked and the soil on which they grew. The ratio of stem weight (i.e. trunk and branches) to root weight was comparatively constant under given soil conditions, however, irrespective of the size of tree and the crop it had borne. This is an important point, throwing new light on the inevitable effect of branch treatments on the roots, and root treatments on the stems throughout the life of the tree. The stem root ratio varied between different soils. On loam it was about 2·2. On clay 2·1, and on sand about 0·9. Hence it required more than twice as much root to support a given amount of top on the poor sand as on the loam or the clay (3). This is doubtless a true reflection of the "fertility" ratio of the soils. Similarly in an excavation of manured and unmanured pear trees it was found that the stem root ratio of an eight-year-old Dr. Jules on Quince A, not manured, was 2·17, while that of a sister tree manured with farmyard manure was 2·57.

Root Observation Trenches. Actual observations on growing roots have been carried out during the past four years in special observation trenches installed in the orchard at East Malling, and also in an irrigated orchard in British Columbia during the writer's stay there in 1932 (6). In these observation trenches plate-glass observation windows are supported against the soil profile, reaching from the surface to 4 ft. deep. The windows are uncovered periodically in order to observe the roots which grow against them. It has been found possible to record the period, position and rate of new root growth, and to note the suberization of the root and its subsequent behaviour. The root hairs can be studied with a microscope and photo-micrographs can also be obtained. Soil temperature records are taken. Soil moisture records are obtained with a Soil Moisture Recorder, an instrument developed at East Malling, a full description of which will be found elsewhere in this report.

* 100 cm. = approx. 3 ft. 3½ in.

Records taken in these observation trenches showed that as the soil temperature rose, the root growth, as shown in both number and length of roots, increased also. A fall in temperature was followed by a fall in root growth. When the soil became drier, however, the root growth decreased although the temperature was rising. When irrigation was applied the root growth rose again sharply. Similar responses were seen throughout the season. Thus it appears that root growth has varied directly with soil temperature, with sufficient moisture as a limiting factor. The observation trenches at Malling have confirmed this point in two recent drought years.

The new roots are white with numerous tiny root hairs. After a period of two to four weeks these hairs shrivel up, and the cortex becomes suberized—finally sloughing off through the action of soil insects and organisms. The root is thus left loose in its hole until secondary thickening begins. Many of the finer roots rot away entirely, leaving numerous channels which must be of great value in aerating and draining the soil. Meanwhile new root growths continue to comb the soil through and through.

At Malling the greatest root growth occurs in June, July and August. There is some, but very little, growth in the winter.

Conclusions.

The general conclusions from this work are that the root will grow anywhere it can in order to get what it requires. It is easier for the root to grow into new areas of soil containing its requirements, than for plant nutrients to move to the roots. On areas bearing a crop all the available soil will be used by roots subject to the incidence of limiting factors, of which some of the most important are (1) age and varietal habit of plant, (2) mechanical factors such as hardness of soil, rock, etc., (3) physical factors such as moisture, aeration and temperature, (4) nutritional factors. Many of these factors can be controlled by choice, by cultivation or by amelioration. The soil is the reservoir of plant foods, hence the deeper the soil and the more the possible root range the better the plant growth will be.

Summary.

The root growth of mature apple trees on loam, sand and clay is described and compared. The relation between root and stem growth and various soil factors, as shown by excavations and in root observation trenches, is discussed. Various limiting factors including soil hardness, fertility, aeration and moisture are noted.

The importance of further study of root growth in relation to soil factors is emphasized.

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(3) ——— and ——— 1934. Journ. Pom. and Hort. Sci., XII, 110-50.

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(7) ——— 1935. J. Agric. Sci., XXV, 326-43.

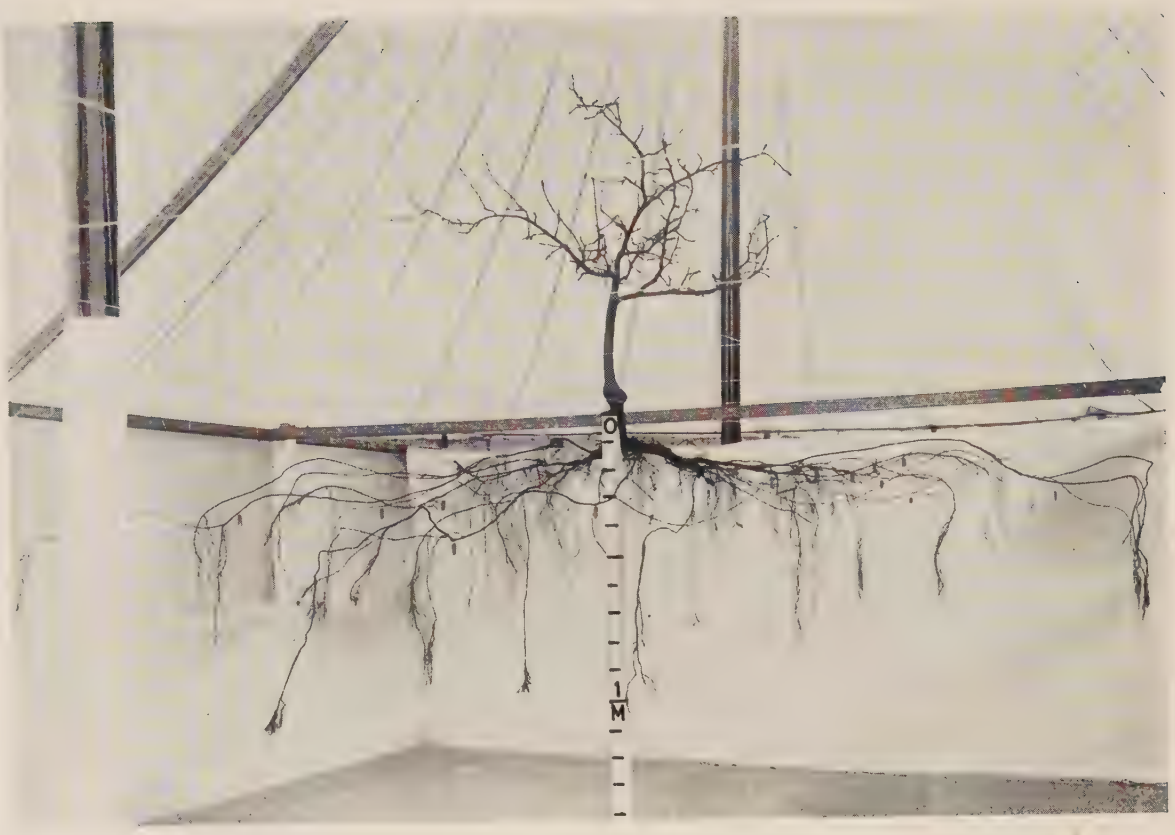


FIG. 1.

Ten-year-old Lane's Prince Albert apple on Stock No. II. Excavated from Sandy soil.

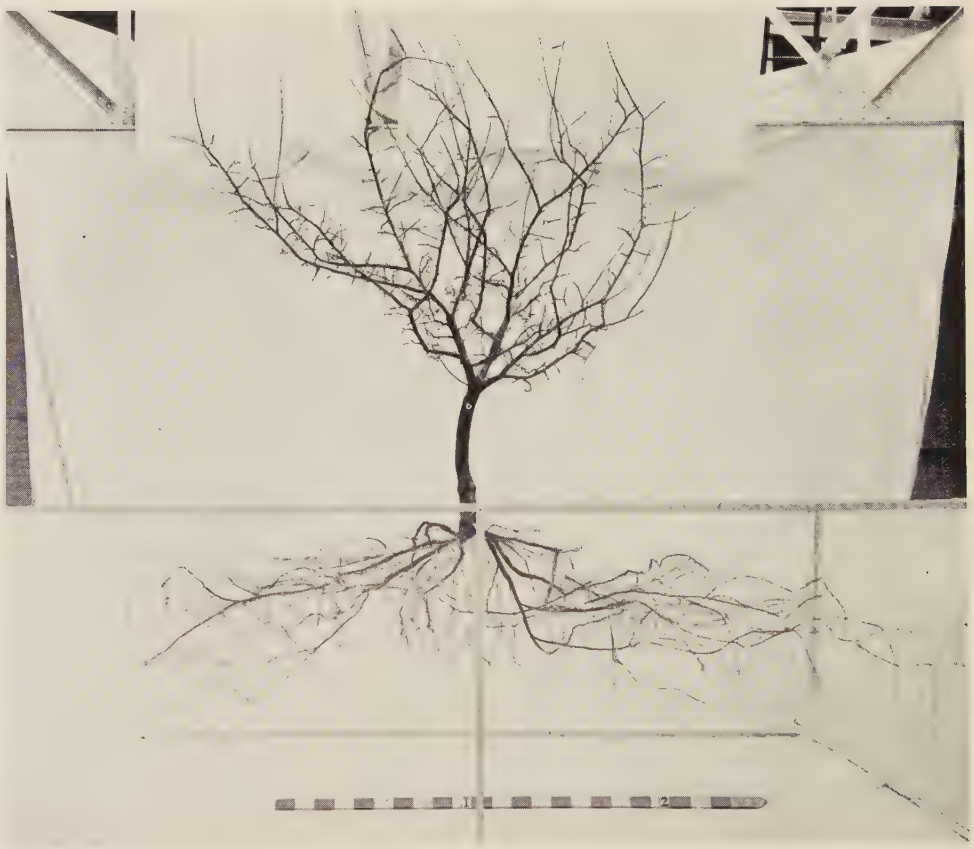


FIG. 2.

Reconstructed root-system of eleven-year-old Lane's Prince Albert apple on Stock No. II. Excavated from heavy Clay soil. The measure is marked in metres and tenths. (1 metre = approx. 3 ft. 3½ in.)

SOME NOTES ON ONE YEAR'S EXPERIENCE WITH A GAS STORE

By A. C. PAINTER

In the ordinary course of events one would greatly hesitate to draw deductions from the results of one year's experience in storing apples in a gas store. Yet those obtained at East Malling during the 1934-5 season have so strikingly confirmed the findings and warnings of research workers of the Food Investigation Board (1) that no apology is made for referring to them in the hope that they may be of some value to other users of gas stores, more especially those who are perhaps operating one for the first time.

It should be made quite clear at the start that the gas storage chambers at East Malling are ordinary commercial stores and are not being used for the purpose of carrying out controlled storage experiments; they are merely for the commercial storing of fruit grown on the Station. The conditions and problems, therefore, though a good deal accentuated in our case for the reasons stated below, are otherwise such as might confront the ordinary commercial grower.

Owing to the fact that records of some description and, in a considerable number of cases, very detailed records, have to be taken on all fruit grown on the Station it was not possible on this occasion to pick, grade, and get the fruit into store within the short time that is recommended as being desirable. On the other hand, it is owing to this very fact that it is possible to give some warnings and point out what may be expected if this is not done.

The plant consists of three chambers, each with a capacity of some 2,000 bushels. For the sake of convenience these chambers will be referred to by the numbers by which they are known at the Research Station. All were filled, as shown, the fruit being loaded into trays holding approximately two-thirds of a bushel.

There was no planned experiment; all that was done was to take a rough record of the wastage from each plot at unloading, together with some general notes on the behaviour of the fruit.

Unless specifically stated, particulars of wastage and other remarks refer to fruit of "Fancy" grade, as comparatively little "Domestic" or "Cull" fruit was stored, and it furthermore enables a simpler comparison to be made.

Details of Loading, Wastage, etc.

Chamber No. 1.

Variety.	Bushels Stored.	Quality Grade.	Approximate Wastage.		
			Over $3\frac{1}{2}''$ in size.	$2\frac{1}{2}''$ to $2\frac{3}{4}''$ in size.	Average for all grades.
Bramleys ..	1,770	Fancy	3·5%	2·0%	2·25%
	340	Domestic and Culls	—	—	4·00%

Loaded between 3rd and 11th October, from one to nine days elapsing between picking and storing.

Unloaded and marketed between 24th April and 9th May, "Fancy" fruit of 2½ in. and above selling at from 9s. to 12s. a bushel according to size and time of marketing.

Average period of storage seven months.

CHAMBER NO. 3.

Variety.	Bushels Stored.	Quality Grade.	Approximate Wastage.		
			Over 3½" in size.	2½" to 2¾" in size.	Average for all grades.
Bramleys ..	1,640	Fancy	1·75%	0·75%	1·25%
	260	Domestic and Culls	—	—	2·5%
Lanes ..	110	Fancy	No record.		
	7	Domestic and Culls			

Loaded between 12th and 23rd October, from one to nine days elapsing between picking and storing.

Unloaded and marketed between 10th and 24th April, "Fancy" fruit of 2½ in. and above selling at 8s. to 11s. 6d. according to size and time of marketing.

Average period of storage six months.

CHAMBER NO. 2.

Variety.	Bushels Stored.	Quality Grade.	Approximate Wastage.		
			Over 3½" in size.	2½" to 2¾" in size.	Average for all grades.
In Storage Trays :					
Bramleys ..	220	Fancy	15%	2%	6%
	330	Domestic and Culls	—	—	7%
Lanes	740	Fancy	20%	2%	7%*
	90	Domestic and Culls	—	—	10%
Edward VII ..	190	Fancy	Negligible		
	30	Domestic and Culls			
In Standard Boxes	*Packed for*	*Market :*			
Lanes	420	Fancy	30%	2·5%	15%*
Edward VII ..	115	Fancy	—	—	1·25%

* No direct comparison is possible between these figures owing to abnormal wastage from one plot greatly accentuating that from the boxed fruit, but see page 216.

This chamber was definitely reserved for odd lots, being loaded between 23rd October and 2nd November. The Lanes were placed in store from five to sixteen days, the Edward VII from eleven to thirteen days, and 250 bushels of Bramleys from twenty-one to thirty-five days after picking. As there were then no other apples available for storing the chamber was sealed down on 2nd November, being opened again on 22nd November to receive another 300 bushels of Bramleys, which had been picked some six to eight weeks.

The fruit was unloaded and marketed between 13th March and 9th April, "Fancy" Bramleys of $2\frac{1}{2}$ in. and above, marketed between 13th and 27th March, selling at 5s. 6d. to 9s. a bushel according to size and time of marketing, "Fancy" Lanes, marketed between 28th March and 9th April, at 6s. 6d. to 10s., and Edward VII, marketed between 26th March and 1st April, at 7s. to 9s. 6d. a bushel.

Average period of storage five months.

Note.—Generally speaking "Domestic" quality fruit fetched approximately 1s. a bushel less than "Fancy" grade and "Cull" fruit from 2s. to 3s. less.

Comparison between Results in Different Chambers.

To get a true perspective of the results obtained, it should be borne in mind that experiments carried out at Ditton Laboratory have conclusively shown that, provided the fruit is picked before it has become too mature, is got into store at once, and treated properly when in store, it will almost certainly keep in practically perfect condition over a period of at least six to eight months.

Chambers 1 and 3 illustrate what may be expected to happen if there is some slight delay in getting the fruit into store, whilst the serious effect of long delay is well brought out in the case of No. 2.

Chambers 1 and 3 were loaded under very similar conditions. In both the wastage was low—in No. 3, where the fruit was stored for some six months, being only 1·25 per cent., and in No. 1, where it was stored for seven months, 2·25 per cent. Further, there was no great difference in wastage between large and small sized fruit. The difference between the wastage in the two chambers is probably mainly accounted for by the fact that the fruit in No. 1 was stored for about a month longer than that in No. 3.

In Chamber 2, though the fruit was marketed from one to two months before that in the other chambers, not only was the average wastage much higher, but there was also a very marked difference between the wastage percentages of the larger and smaller sized fruits. Further, instead of being able to store and bring out the fruit when desired, the problem was to hold it sufficiently long to enable advantage to be taken of a steadily improving market before wastage became unduly high.

Whilst good prices were obtained, nevertheless those for the Bramleys (which are the only ones which can be compared) were from 2s. to 3s. a bushel less than those obtained later for fruit of similar quality from other chambers. Whilst these prices were such as to render storage amply worth while in spite of wastage, it must be remembered that the time will inevitably come when the margin of possible profit will be considerably smaller and that then a high or a low percentage of wastage may well make all the difference between profit and loss.

Once again it may be emphasized that the great difference between the wastage in Chamber 2 and Chambers 1 and 3 can be almost entirely accounted for by the long time that elapsed between picking and storing in the case of No. 2. What actually happens in such cases is that the advantages of gas storage are largely nullified and in these circumstances severe wastage from rot-producing moulds must be expected.

General Notes on Keeping Quality.

In each chamber the fruit came from several different plots, comprising trees of differing ages and receiving varying cultural and manurial treatments.

Marked differences were observed in the keeping qualities of fruit from these different plots, e.g. the wastage in Bramleys from a plot that had received nitrogen was definitely greater than that from a similar plot that had had none. Again, the wastage from one plot of Lanes was abnormally high, being approximately three times that from any other. No specific reason can be given for this last, but it was possibly due to the fact that the fruit came from young trees on cultivated land.

Where the average wastage was low there was little difference between that of large and small sized fruit, but, as the average wastage increased, this difference became progressively larger.

Fruit Packed Ready for Market.

To test the feasibility of storing fruit packed ready for market, some 420 bushels of Lane's Prince Albert and 115 bushels of Edward VII were packed in standard boxes and stored in Chamber 2. These represented two extremes in that the Lane is a variety liable to be easily bruised, whilst the Edward VII were exceptionally firm and of extremely good keeping quality.

Where a direct comparison was possible the wastage in the boxed Lanes varied from 4 per cent. with $2\frac{3}{4}$ to 3 inch fruit to 20 per cent. with fruit of over $3\frac{1}{2}$ inches in size, the corresponding figures for comparable fruit in trays being 2 per cent. and 15 per cent. There was, therefore, a somewhat higher wastage in the boxed fruit.

With the Edward VII, wastage was also higher in the packed boxes. In both boxes and trays, however, it was extremely low, being only a little over 1 per cent. in the former and negligible in the latter. A certain amount of scald was also present—here again it was more extensive in the boxed than in the trayed fruit.

Had the Edward VII in this case been got into store as soon as picked, the boxed fruit would have almost certainly kept in practically perfect condition but it should again be emphasized that this fruit was of exceptionally good quality. On the other hand it is thought that very great care would need to be exercised with a variety that is easily bruised, like Lane's Prince Albert.

It is proposed to carry out further trials in this connection.

Grading of Fruit after Storing.

As some growers may desire to put fruit into store without it being first of all graded for size so as to reduce the interval between picking and storing to a minimum, a small test was made to see how fruit that had been stored would stand up to machine grading.

The fruit used consisted of Bramleys, of $2\frac{1}{2}$ to $3\frac{3}{4}$ inches in size, from a grass plot that had received a liberal dressing of nitrogen. It had been picked on 30th September, stored on 4th October, and brought out of store on 5th May. Five bushels were passed over the Cutler grader on 9th May and a similar quantity put aside (note : all the fruit had already been Cutler graded before storing in October). The fruit was examined for blemish on 1st, 7th, and again on 20th June. Only by the most careful examination could any difference be seen : from the marketing point of view there was no difference whatever between the apples put over the grader and those not.

The fruit it will be noted came from trees on grass (there was no other available at the time). Possibly other fruit, such as that from heavily nitrogened trees on cultivated land, might not have stood up as well, but the indications are that most fruit, provided it has been properly stored, can be put over a grader after storing without any greater damage ensuing than if it had been put over before storing.

Some Recommendations.

The lessons to be drawn may be summed up as follows :

1. To obtain the best results it is essential that the fruit should be picked before it has got too mature, and that it be got into store and the store sealed down within the shortest possible time. The recommendation now made by the research workers of the Food Investigation Board is that, if possible, not more than two days should elapse between the picking of the fruit and the sealing of the store and in no case is it wise to allow this period to exceed five days. The same workers have shown that, if this is done, and the correct temperature and gas concentration maintained, then so far as ordinary rotting and breakdown is concerned, there is likely to be little difference between the keeping qualities of fruit grown under different manurial and cultural conditions over any period required by ordinary commercial practice. (These remarks do not apply to bitter pit, which is a problem in itself.)

2. If for any reason it has not been possible to get the fruit into store within the time recommended, then wastage, increasing with the time that elapses between picking and storing, must be expected. There may also be considerable differences in the keeping qualities of fruit from different plantations, e.g. generally speaking, fruit from grass will keep better than fruit from cultivated land, fruit from trees that have had little nitrogen better than those that have had a liberal application, fruit from old trees better than that from young trees, and so on. A much higher percentage of wastage must also be expected from large-sized fruit than from small.

This being so, a grower would under such circumstances be wise to endeavour to keep fruit from different plantations in separate stores, or, at any rate, only to mix fruit from those which have had somewhat similar treatments, and either to keep out altogether large-sized fruit and fruit that for any reason he does not anticipate will keep well, or store it so that he can remove it at the first sign of its breaking down.

3. There are not enough data at present to say whether it is safe to store fruit packed ready for market, but it can definitely be said that it would be most unwise to attempt to do so unless it is first of all carefully picked and graded and then stored under the best conditions.

Readers, desirous of further information, are advised to refer to Food Investigation Leaflet No. 6, *The Refrigerated Gas Storage of Apples*, which can be obtained on application to the Superintendent, Ditton Laboratory, East Malling, Kent, to whom general enquiries on the subject of gas storage can also be made.

Acknowledgments.

The writer is much indebted to Dr. Cyril West of Ditton Laboratory for reading through these notes and making various suggestions, also to Miss B. L. Wates for assistance in summarizing the records.

Summary.

1. Some results of a year's experience with a gas store confirmed the findings of other research workers.

2. Where the interval between picking and storing of the fruit was short, the percentage of wastage was low, and there was no great difference in wastage between large and small sized fruit. Where the interval was long, wastage was high with a big difference between large and small fruit.

3. Marked differences were observed in the keeping qualities of fruit from different plantations.

4. A preliminary test on fruit packed ready for market indicated that it would be unwise to attempt to store fruit in that way unless it is first of all carefully picked and graded and then stored under the best conditions.

5. Bramleys from a grass plot were put over a Cutler grader after storage without detracting in any way from their commercial value.

6. Arising out of the above a number of recommendations are made as to precautions to be taken when gas storing fruit.

7. An estimate of the cost of gas storage is given.

Reference.

(1) Kidd, F., and West, C. "The Refrigerated Gas Storage of Apples." Department of Scientific and Industrial Research Food Investigation Leaflet No. 6.

APPENDIX.

Cost of Running a Gas Store.

As enquiries are often made as to the cost of running a gas store the following estimate, based on one year's experience, may be of interest, and indicate to the grower what sort of charges he should allow for.

When considering these costs, however, it must be remembered that they may vary somewhat with different circumstances, e.g. electricity charges may differ from district to district, and the number of units consumed will depend on the length of time the fruit is stored and on how long it is necessary to run the plant.

The costs are based on a unit consisting of three storage chambers, each with a holding capacity of some 2,000 bushels, complete with refrigerating machinery and electrical recording equipment, and costing, say, £1,500.

One Season's Costs.

Essential Charges.	£	s.	d.
Electric current at an average of, say, 1d. per unit. (At East Malling some 10,500 units were consumed over a period of 31 weeks.) ..	44	0	0
Depreciation on chambers and plant (not including outer building) 7½% on £1,500	112	10	0
Interest on £1,500 at 5%	75	0	0
Maker's service charge for maintaining and overhauling machinery and electrical equipment, say	18	0	0
Fire Insurance	1	10	0
	£251	0	0

or 10d. a bushel.

Optional Charges.

There are other costs which a grower, who intends to store his fruit regardless as to whether he has gas chambers or not, may incur in any case. One may wish to charge these up against the gas storage, whilst another may not. Some such are :

	£	s.	d.
Loading and unloading of store—not more than ¾d. a bushel	19	0	0
Oiled wraps. This will depend on the size of the apple being packed—with a cooking apple, say 3d. a bushel	75	0	0
Depreciation of storage trays, allowing for 9,500 at 7d. each, say 15% on £275	42	0	0
	£136	0	0
	or 5½d. a bushel.		

Total Charges (Essential and Optional), 1s. 3½d. a bushel.

INVESTIGATIONS OF FROST DAMAGE TO HORTICULTURAL CROPS, WITH SUGGESTIONS FOR FUTURE WORK*

By W. A. BANE

BEFORE giving the results of this survey it is perhaps necessary to describe briefly its origin and scope.

When the severe but patchy effects of the frost of 16th-17th May, 1935, became apparent, it was thought at the East Malling Research Station that there was a unique opportunity for investigating the various factors involved in the occurrence of frost and its damage to horticultural crops.

Accordingly several members of the Pomology Staff of the Station made a detailed survey of as many farms as possible in parts of Kent, and this was supplemented with information obtained from the fruit-growing members of the Research Station. The survey covered parts of the Lower Greensand or Ragstone, the Hastings Beds or High Weald, the Swanley area and North Kent.

The main limitation of such a survey is the fact that there are nearly always unknown or uncontrolled factors. A list of factors that may conceivably affect the amount of frost damage—altitude, aspect, shelter, manuring and cultivation, age of tree, state of the blossom and varietal susceptibility—shows how complicated the whole question is. There are also to be considered the apparent amount of damage before or after the frost and the presence of a pollinating variety.

The first factor of which many farmers probably think in connection with frost damage is altitude. Height in itself, however, is no protection against frost ; nor are all low places subject to severe damage. On both the Lower Greensand and High Weald, height in relation to the surroundings was found to be of more importance than actual altitude.

In general, however, low places were frosted, and in the following table, based on the replies to the questionnaire, there is an indication that more fruit was lost at low altitudes than at high altitudes.

TABLE I.

	feet. 0–100	feet. 100–200	feet. 200–300	feet. 300–400	feet. 400–500	feet. 500–600	feet. 600–700	feet. 700 +
					Number of plantations very small.			
Percentage of lost crops..	38·9	44·5	34·0	34·0	27·0	—	—	—
Percentage of †Z crops ..	14·3	33·3	22·6	18·4	36·4	33·3	—	—
Percentage of fair crops..	34·8	11·0	13·6	18·4	27·0	33·3	—	—
Percentage of full crops..	12·3	11·1	29·5	29·0	9·1	33·3	—	100

* Reprinted from the *Journal of the Ministry of Agriculture*, Vol. XLII, pp. 1,212-18, March, 1936, by permission of the Controller of H.M. Stationery Office.

† Z crops are those where, in sloping plantations, there is more fruit at the higher level.

Between the altitudes of 0 and 100 feet there were fewer losses and more fair and full crops than one would expect. This is probably due to the warming effect of the sea. Above 100 feet the percentage of lost crops decreases and that of fair and full crops increases, with increase in altitude. This may be because in South-East England, plantations lower than the surrounding land are less frequent at high altitudes than at low altitudes.

There were many strange effects of this frost and some apparently inexplicable, but much that is apparently contradictory may be explained on the following hypothesis. The north-east wind that had possibly caused considerable damage during the days preceding 16th May was still blowing very gently in many places during the night of 16th-17th May. As the freeze began and very cold air collected, this light wind removed the cold air from plantations into which it was able to blow, and though cold itself, did much more good than harm. This hypothesis is supported by the replies to the questionnaire. To illustrate the point it is necessary to describe the system on which they were classified.

TABLE II.

EFFECT OF ASPECT.

" H " Plantations.

	North.	East.	South.	West.
	%	%	%	%
Lost crops	18·5	21·4	20·3	19·3
*Z crops	10·1	18·6	28·2	38·8
Fair crops	32·0	21·5	24·9	21·5
Full crops	39·3	38·4	26·4	20·4

* See Table I for definition of Z crops.

Plantations were divided into two groups—" H " and " L ", the first on hill-tops and the higher parts of hillsides, and the second on lower parts of hillsides, valley bottoms and low plains. These were then sub-divided into four groups, according to whether they were flat or on a gentle, medium or steep slope. Within each of these groups were four further sub-divisions for aspect. The plantations were also divided according to the crop—those in which there was total loss, a fair or full crop, and where there was less fruit on the lower than on the upper parts of a slope. While the numbers in some groups are small, Table II shows that with " H " plantations there are more full crops in those with north and east aspects than in those facing south and west. Though these differences are not significant, the smaller number of Z cases in plantations with north and east aspects is a further point in support of the hypothesis. With " L " plantations the differences are much smaller. The importance of air drainage is well shown in the absence of lost crops and the preponderance of full crops on steep slopes (Table III). Z crops are found most frequently on medium slopes.

As far as the effect of the early morning sun is concerned experience is contradictory. If a plantation was exposed to the sun on the early morning of 17th May, it was also exposed to all the north-east wind that blew before the frost, and either factor, or both, may have been responsible for the damage. This wind may have had a bad effect in more than one way. It may have reduced pollination, either by preventing the bees from working or by so lowering the temperature and drying the stigmas that the process of fertilization was made impossible. It may also have so cooled exposed plantations

that when the temperature became further reduced, resulting eventually in frost, they suffered more severely than plantations that were sheltered.

This leads directly to the question of wind-breaks or shelter belts. As already indicated, it may be that where the light north-east wind blew into a plantation during the night, it was helpful. On almost flat land at higher altitudes, the good effect of shelter belts in keeping the plantation warm before the frost may have been more than enough to counterbalance their bad effect in keeping wind out during the night. In fact, there were found a number of high, almost flat, well-sheltered plantations in which there was a good crop. There were also plantations, on a slope, in which the only fruit was immediately below shelter belts at right angles to the direction of slope, and from the point of view of frost, such belts are definitely harmful, since they retard the flow of cold air down the slope and cause it to pile up against them. Warm air coming from within a wood or thick belt of trees and spreading a few feet outwards is probably the cause of fruit being found on a tree or half a tree immediately adjoining. Here again there may be alternative explanations, such as shelter from wind before the frost or protection from the early morning sun following it.

TABLE III.

EFFECT OF SLOPE.

"H" Plantations.

	Gentle.	Medium.	Steep.	Mean.
	%	%	%	%
Lost crops	35·3	24·3	0	19·9
*Z crops	19·5	33·9	18·3	23·9
Fair crops	15·8	22·5	36·6	24·9
Full crops	29·3	19·1	45·0	31·1

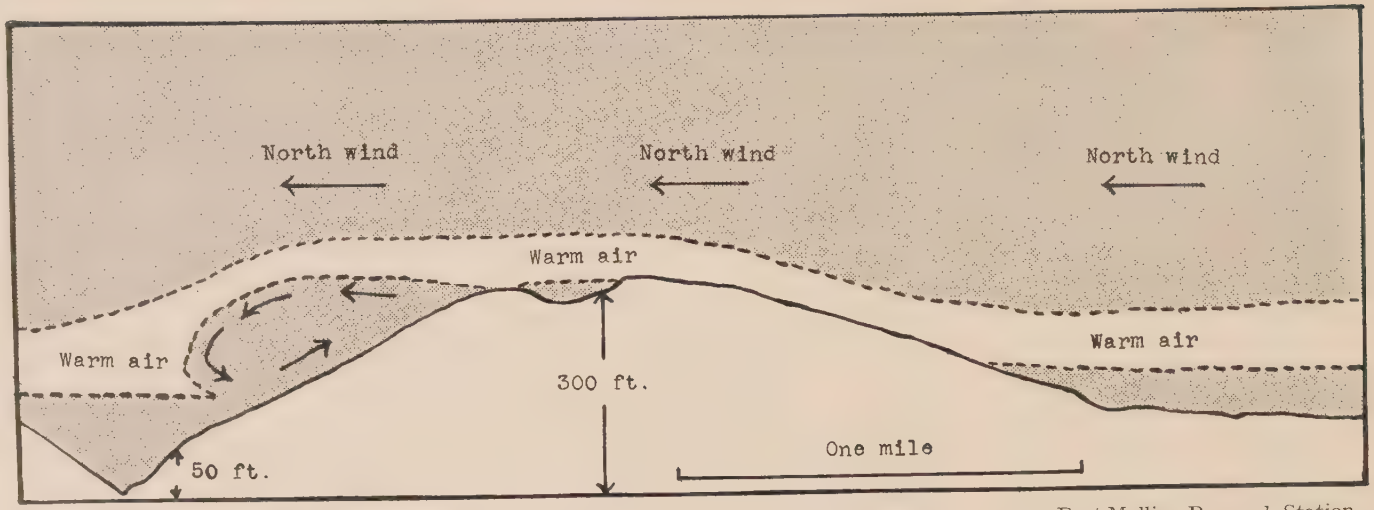
* See Table I for definition of Z crops.

Where the land was in a stepped or terraced form with a southern slope, fruit was only found in the lee of the ridges, with an entire lack of crop in small valleys cutting through them. This may have been due to the cold air flowing down the slope with some velocity, passing over the part in the lee of each ridge and collecting in the valleys.

The evidence regarding the effect of manuring, cultivation and age of tree on the amount of damage, was also contradictory. Manuring and cultivation are closely connected with each other and with time of blossoming.

Many people wonder whether the blossom following two heavy crops would have been strong enough to set well had there been no frost. From the fruit seen in healthy plantations that escaped the frost, it appears probable that it would have set. In some crowded plantations, however, it might have been too weak to set except on outside trees, which get more light and food and can form strong fruit buds even when carrying a crop. There is also the possibility, however, that cold air in the middle of such plantations remained stagnant, whereas round the edges it was moved by the light wind.

The last factor, but by no means the least important, is varietal resistance. The value of this was stressed by Mr. H. V. Taylor in a paper read at the Conference of Empire Meteorologists in 1929. He gave the comparative resistance of the main varieties of apples, plums, pears, black currants, gooseberries and strawberries as shown by the reports made to the Ministry of Agriculture. While the East Malling survey has not



R. Medway, Wateringbury. Escarpment. Dip Slope. East Malling Research Station.

A diagram of probable atmospheric conditions on the night of 16th-17th May, 1935, between East Malling and Wateringbury. Cold air is represented by the stippled regions, the positions of which have been inferred from the amount of frost damage occurring on fruit trees and other plants. Note the accumulation of cold air over the Research Station causing severe frosting of crops, and the warm air on the dip slope carried into contact with the ground by the light north wind and resulting in no severe frosting of the crops. Note also the accumulation of cold air in the high valley and in the Medway Valley. The eddy shown, caused by the light north wind, has been inferred from the fact that cold air did not drain off the escarpment. It should be realized that, *under the conditions shown*, attempts to aid the drainage of cold air by trenches, ridges of soil or oblique wind-breaks on the escarpment would probably be futile. It will be seen that much depends on the wind direction at the time of the frost.

received reports or made notes on as many varieties as were then given, those that it has are in the main in the same order. Several variable factors are concerned, including the date and duration of the blossoming period, the relative susceptibility of varieties, and differences in susceptibility of one variety at various stages in development from the bud to the fruitlet. Where the susceptibility of different varieties appears to vary from year to year it may be that, though the relative order of blossoming is the same, the frost comes at a different point in the whole blossoming period.

To sum up, emphasis should be laid on the value of height relative to that of the surrounding land ; the good effect of nearness to large rivers or the sea ; the lack of evidence with regard to manuring and cultivation ; the good and bad effects of wind-breaks, and the variation in susceptibility to damage among varieties.

The results of this survey and a review of the literature made by Mr. C. Cornford, with the aid of the Imperial Bureau of Fruit Production, have shown that information is required in a number of directions if the full benefits of frost prevention are to be obtained.

The susceptibility of the plant to frost damage is of primary importance and should be found for each kind and variety of fruit, with the exact nature of damage to the various parts of the tree, and the effect of rootstock, age of tree, density of foliage, manuring and cultivation. The effect of early morning sunshine on frozen tissue and of cold winds before and after the frost should also be considered.

It is hoped that some of the limitations of existing methods of frost prediction may be overcome and that it will be possible to investigate various methods of frost prevention. The most important phase of such investigation would be concerned with air currents and cold air drainage and would be a continuation of work begun by G. S. P. Heywood. Katabatic winds, i.e. winds caused by the flow of cold air down a slope, are of considerable importance in connection with the prevention of frost damage, as they may not only influence the severity of frost within any given orchard but also modify the results of heating the orchard. An accurate knowledge of such winds should enable the farmer to increase the efficiency of heating methods. In some plantations it would lead to the abandonment of heating methods, while in others the heaters could be placed in positions of maximum advantage. The East Malling survey included visits to several farms on which orchard heating was practised. At that of Mr. Harrington of Bedford the heaters appeared to have prevented frost damage. Further reference is made to these results by Mr. Hoare (see p. 1218, *Journ. Min. Agric.*, March, 1936). On a large farm in Kent a similar success was obtained. On some others, however, results were rather less definite. One farmer had obtained very good results in a valley that had been regularly frosted in previous years, but used seventy-five heaters to the acre and had to re-fuel after four hours' burning. This failure of the lamp to burn for the normal time was also reported elsewhere. On still another farm crops were equally good in heated and unheated areas, and it is therefore doubtful whether in this instance the frost was severe enough to cause damage in any event.

The experience of 1935 has shown the need for further investigation of the frost problem, but growers would probably benefit greatly by work on the many other meteorological factors that play a part in the production of high quality fruit, and it is hoped that such investigations will be part of a much wider scheme of research.

INSECTICIDES AND FUNGICIDES

THE USE OF DERRIS ROOT AS AN INSECTICIDE

By W. STEER

For many years, usually under various proprietary names, Derris root has been used in this country, not only as a spray for fruit trees, hops and garden crops, but as an ingredient also of cattle and sheep washes and domestic insect powders.

There are four forms in common use :

1. the finely ground root, for use with soap or other wetter,
2. the ground root ready mixed with dried soap or other wetter and requiring merely the addition of water,
3. an extract of the root, usually in an emulsified form, ready for dilution with water, and
4. the ground root mixed with a suitable " carrier " or " filler " such as China Clay and intended for application as a dusting powder.

Of these, Nos. 1 and 4 are the most popular, whilst No. 2 is the form in which Derris is generally purchased for garden use. The ground root can be obtained at prices ranging from 2s. to 2s. 6d. per pound, and, since the usual dilution is about 2 lb. per 100 gallons, a Derris spray costs about 4s. 6d. per 100 gallons (without wetter). The prices of dusting powders vary, but a dust of 0·2 per cent. rotenone content can usually be purchased at 30s. to 35s. per cwt.

There is, unfortunately, no easy chemical method of evaluating the toxic properties of the root, although a great deal of work on this problem has been carried out in this country (notably at Rothamsted) and in America. It is generally assumed that the " rotenone content " is an index of the insecticidal value of the root, and samples of Derris of declared rotenone content can now be obtained. Although the rotenone content has generally been found to be a safe guide and sprays containing approximately 0·005 per cent. rotenone have given good results, there is some doubt as to whether the rotenone content (as estimated by present methods) is an adequate indication of the toxicity of the root.

At present some firms sell Derris of definite rotenone content whilst others prefer to supply it standardized by other methods. When buying Derris root, whether on a rotenone or other basis, it is advisable to obtain it in a fresh condition from reliable merchants who can offer a reasonably well-standardized article.

The nature of the insecticidal action is not completely understood. Derris certainly acts both as a direct and as a residual contact insecticide, but it is thought to act also as a stomach poison. It is compatible with any of the sprays in common use (such as Bordeaux mixture and lime sulphur) but constant agitation of Derris-containing sprays is advisable to prevent the somewhat heavy particles of the ground root from settling out.

The Value of Derris in the Control of Specific Pests.

Derris has for many years been used for caterpillar control in grass orchards where lead arsenate is considered unsafe on account of stock grazing beneath trees. It has long been used, also, as a hop wash, chiefly for aphis. Various forms are commonly sold and used for garden pests such as " green fly ", " black fly " and caterpillars and other leaf eating insects.

At East Malling Research Station Derris was first used experimentally in 1928, when a non-poisonous spray was required for late application to raspberries to control the larvae of the Raspberry Beetle. These experiments were continued in subsequent years on raspberries, loganberries and blackberries, with various forms of Derris (including a powder suitable for dry application first made and tested here in 1931). The successful outcome of these experiments led to a great increase in the use and popularity of Derris both as a wet spray and as a dusting powder.

Derris has now been tested against a fairly wide range of pests at East Malling and at other research centres. It has proved of particular value against some insects, e.g. Raspberry Beetle and Flea Beetle on hops, of uncertain value against some aphids, reasonably effective against many leaf eating insects, and of some promise against Red Spider.

Red Spider. On damsons in 1934 Derris and soap, applied on 18th May, was substantially as effective as lime-sulphur. The reduction in the amount of Spider caused by these sprays and indicated by counts of summer eggs subsequently laid on the leaves was 92 and 97 per cent. respectively. On apples (Lane's Prince Albert) applied at petal fall (26th-28th May) Derris appeared to reduce Spider by about 80 per cent., but doubt was cast on the validity of this figure by the anomalous results obtained with certain other sprays, one of which was a petroleum oil spray.

It can safely be said, however, that Derris showed great promise and is worthy of trial for the control of Red Spider where lime-sulphur cannot safely be used.

Apple Sawfly. In experiments carried out here and elsewhere Derris has proved useful against Apple Sawfly when used as an ingredient of the petal fall Scab spray. When so employed it is less effective than nicotine applied prior to hatching of the eggs, but of similar effect to nicotine applied just after the beginning of hatching. This difference is due to the fact that nicotine can act as an ovicide whereas Derris is apparently effective only against the larvae themselves. Where a petal fall spray has been omitted, Derris dust can usefully be employed to prevent attack by migrating larvae.

Plum Sawfly. Derris does not appear to have been a marked success against this pest,* but observations made in 1934 suggest that it might, with advantage, be used in a dry form against migrating larvae when the first signs of secondary attack are observed.

Aphids and similar soft bodied sucking insects. Although Derris and soap is highly toxic to this form of insect life, a dry powder appears to be less efficacious. Thus a Derris dust failed to control a bad attack of *Capitophorous ribis* on Red Currants in a garden in June, 1935, but, when a wet spray was used, satisfactory results were obtained.

Raspberry Beetle. Commercial usage has now borne out the results consistently obtained in our experiments against this pest. A single spraying of Derris and soap gives perfectly satisfactory results. On raspberries and loganberries this should be

* Since this article was written an important paper on the control of Plum Sawfly has been published (Petherbridge, F. R. and Thomas, I., *Journ. Ministry of Agriculture*, 1936, **42,** 1,108-18) which records that Derris was used successfully, applied twice, when the " cots " (receptacles) are splitting and a week afterwards.

applied when the larvae have begun to attack the berries. Under our conditions this is usually towards the end of June or, more exactly, when the earliest berries of the Lloyd George raspberry begin to ripen. Blackberries, such as Himalaya Giant and Cutleaf, should be sprayed a fortnight later. Although the larvae can be killed by late applications of a Derris dust, such treatment is liable to leave an unsightly deposit on the berries. Many growers prefer to attack the adult stage of the pest by means of Derris dusts and so prevent egg laying and subsequent fruit damage. Good results are obtained by dusting during the flowering period but several applications of the dust seem to be required.

Flea Beetle. Derris is very toxic to the various species of flea beetles which attack hops and cruciferous crops. For these insects it is best used in a dry form, either as pure ground Derris and applied sparingly or as a Derris-containing dusting powder and applied more liberally. The young hop bines should be dusted at the first signs of beetle damage and the doses should be repeated as often as necessary until the bines are out of danger (when they have reached the breast wire).

Apple Tortrix Larvae. Promising results were obtained in 1934 with Derris and soap against the tortrix larvae which feed on the skin of the apple and have given so much trouble in stored fruit. Our experiments, however, have not reached the stage when we can confidently recommend the use of Derris sprays or dusts for these pests. For the information of growers who care to experiment with it a trial of Derris dust in mid-July is suggested.

GENERAL

RESULTS OF WALNUT RESEARCH WORK AT EAST MALLING RESEARCH STATION*

By J. B. HAMOND

INTRODUCTION.

The vast majority of walnut trees in this country are seedlings, and of a large collection of nuts from widely different English sources, less than 1 per cent. attained a satisfactory standard of quality. Seedling walnut trees show great variation in their productivity, size and quality, and often take many years to produce a crop. Therefore grafted walnut trees of the most suitable varieties for our climatic conditions should be planted.

A good nut should have the following characteristics :

(*a*) Size.—Not less than $1\frac{1}{8}$ in. in diameter.
(*b*) Weight.—Not more than 30 to 40 per lb.
(*c*) Contour.—Absence of deep pitting, corrugation and irregularity in form.
(*d*) Colour.—Light brown or golden brown.
(*e*) Sealing.—Should not open at all with moderate pressure between finger and thumb.
(*f*) Cracking.—Should crack readily with ordinary nutcrackers and kernel easily removed without shattering.

Kernel.

(*a*) Colour, with pellicle.—Light tan or silvery brown with glossy waxed appearance.
(*b*) Percentage.—50 per cent. of the total weight of crop.
(*c*) Plumpness.—Shell well filled and kernel unshrivelled, brittle—not leathery.
(*d*) Flavour.—Rich, mild and of essentially walnut flavour, free from woody taste, with little or no astringency.

The following varieties have been selected for vegetative propagation in this country :

French.—Franquette, Mayette, Meylanaise, Treyve.

English.—No. 162 (Ixworth), No. 95 (Gloucester), No. 719 (Margate), No. 589 (Dartford), No. 202 (Ipswich), " Leeds Castle " (Kent), and " Patching " (Sussex) for pickling.

All these varieties are of excellent quality, also they all leaf out late and usually escape our spring frosts.

PROPAGATION.

(*a*) *Rootstocks.*

Seedling stocks of walnuts (*Juglans regia* and *J. nigra*, etc.) are variable even when seeds are obtained from the same tree. At present only such stocks are in common

* Reprinted by permission from the *Kent N.F.U. Journal*, Vol. XXXIX, No. 1, January, 1936.

use. To obtain the best results the nuts as soon as gathered should be stratified in moist sand to keep plump until planted in March.

To obtain standardized stocks to ensure uniformity of performance for any given scion variety vegetative propagation of rootstocks is necessary. A number of varieties can be raised vegetatively ; the method of layering is the same as that used for plum stocks.

(*b*) *Grafting*. (Under Glass.)

Hardwood grafting is carried out in February and March on one-year-old stocks in pots. Scion wood of one or two years' growth, of medium size, firm and well ripened, with a small pith area is used.

Greenwood grafting is carried out in July and August—quite small scions are successful if the pith area is just past the pulpy stage.

Taking an average of ten varieties, the percentage of success in grafting is :

February-March grafting	Plants placed in close frame after grafting	79%
	Plants placed on open bench after grafting	80%
Some varieties as high as		95%
July-August grafting		90%
Average in open ground		10%

In grafting the walnut, unless the ties are firm and lasting, the " callus " from the pith area is liable to push the scion away from the stock and so prevent a union.

Small grafted trees in pots can be transported long distances with a minimum of cost and loss. Such trees make good growth in the first year after planting in the open ground.

Top grafting is seldom satisfactory chiefly owing to extremes of temperature.

(*c*) *Budding*.

Good results have been obtained experimentally by using buds of previous year's wood in May and June. This method may be used on trees up to twenty-five years old.

Pollination.

Walnut flowers are unisexual. Nutlets (pistillate flowers) and catkins (staminate flowers) are borne on the same tree. Young trees often bear nutlets years before catkins appear. Even when both kinds of flowers are present they are not always ripe at the same time. In such cases pollen must be available from trees nearby up to 300 to 400 yards distant, before nuts can be produced. Some varieties bear catkins when quite young, e.g. Meylanaise, and could be interplanted to procure early cropping.

Diseases.

(*a*) *Bacterial Blight*.

This disease attacks leaves, stems and fruits. The following control measures are recommended :

(1) Cut out stem lesions during the dormant season.
(2) Apply a protective spray of Bordeaux mixture (8-8-100) as soon as trees have leafed out in spring.

If late leafing varieties free from disease are procured, little trouble is likely to be experienced, and spraying will most probably be unnecessary.

(*b*) *Graft Disease.*

This disease only causes trouble when the walnuts are being grafted. The following simple method of control has been found effective :

Formalin at 1 per cent. is toxic to the fungus spores, therefore, before the walnut stock is cut, that portion of the stem where the scion is to be inserted should be painted with 1 per cent. formalin.

Identification of Varieties.

At present there is no means of distinguishing between the selected varieties with certainty.

A preliminary survey of the leaf characters of a number of English and French varieties has revealed differences in foliage characters, such as angle of leaf to stem, length of rachis, spacing and size of leaflets thereon, etc., and it is thought that important varieties may be grouped according to the above characters. Other lines of identification —of which nut characters should be important—are being explored.

The following is the method of grouping the selected varieties of *J. regia* on their leaf characters.

Group I. Franquette, Mayette, Meylanaise.

Characters : Compact growth, leaflets rather small, bronze pink colour in young foliage, mature foliage definitely green.

Group II. Woodland, Treyve, No. 719.

Characters : Drooping habit, due to long rachis which is at first upright, eventually drooping. Mature foliage yellowish.

Group III. No. 202, No. 162, No. 95, Goliath.

Characters : Mature foliage tends to be deep green. Leaflets usually horizontal.

Group IV. No. 589, Leeds, Patching.

Characters : Apparently " thin " growth due to long rachis. Mature foliage light green.

Storage.

It is important to remove the husk as soon as it is ready to fall away from nut, as it is here that moulds commence to grow. Traces of the husk which remain in the crevices of the shells should also be removed by washing in water, using a soft scrubbing brush. The nuts must not be allowed to remain in contact with the water for more than a few seconds. They are then dried on trays in a current of air.

When dry the appearance of the nuts may be much improved by bleaching in a solution prepared from chloride of lime and washing soda. This solution is prepared as follows :

Three pounds of chloride of lime are placed in a 5-gallon container and mixed into a creamy paste with a little water. About 2 gallons of water are added, and the mixture is stirred thoroughly ; $1\frac{1}{2}$ lb. of washing soda is dissolved in water in another container, and this solution is poured into the chloride of lime suspension. Water is added to make a total volume of 5 gallons. After stirring the mixture is left to settle for at least twenty-four hours. The clear, supernatant liquid is then poured off and is ready to be used for bleaching.

Walnuts are placed in this bleaching solution for about three minutes, then drained and dried in a single layer.

To store for winter use large earthenware pots are filled with alternate layers of nuts and a storage medium consisting of slightly damp coconut fibre refuse and common salt in equal parts by weight. The pots are then kept in a cool place.

Conclusion.

The above summary of the walnut work at East Malling gives some idea of the methods by which an attempt is being made to improve the quality and quantity of walnuts produced in England. The popularity of walnuts in this country is shown by the fact that in 1934 the total import of these nuts was 125,729 cwt., valued at £366,435. Of these 51,110 cwt. came from France, and 65,858 cwt. from other foreign countries. It is hoped that these figures will show a decrease in the near future, as more walnuts of a high standard are produced at home.

GROWING HEALTHY RASPBERRIES

THE CONTROL OF DISEASES AND PESTS*

By R. V. HARRIS

I. Introduction.

The scope of the present paper is strictly limited to the point of view indicated by its sub-title, i.e. that of the plant pathologist.

For the sake of clarity and brevity and as the raspberry growing industry in this country for the last decade or so has been largely dominated by the Lloyd George raspberry, only those major diseases and pests will be mentioned, serious attacks of which have been observed by the present writer in plantations of Lloyd George, and the descriptions of symptoms and control measures will largely be based on experiments at East Malling and elsewhere on that same variety.

To facilitate their identification and distinction in the plantation, the diseases and pests will be grouped, not according to the nature of their causes, but according to the form of injury they bring about on raspberry stools as follows :

A. Diseases which cause dying back of complete well-grown canes.

B. Diseases and pests which check the development of one or more fruit laterals on well-grown canes.

C. Diseases and pests which directly attack the berries.

D. Diseases which sap the vigour and productivity of stools generally.

Finally, it must be emphasized that a diseased condition in a plantation is commonly brought about by a number of inter-related factors both environmental (non-parasitic) and parasitic, rather than by the sole action of a single agent. Thus, for example, in certain instances the control of cane-spot disease has resulted in increased resistance of canes to the action of late frosts, and an improvement of the nutritional programme has increased the productiveness of mosaic-infected stools. The following survey aims at preserving such a proportioned and inter-related view of the problem of disease control as an integral part of the general scheme of cultivation.

II. Major Diseases and Pests.

A. *Diseases which cause a Die-back of Canes.*

These diseases typically attack actively-growing or well-grown canes, although canes dwarfed by other causes may also be affected.

1. Blue Stripe Wilt—a fungus disease (*Verticillium Dahliae* Kleb.).

This fungus obtains entrance from the soil to the underground root-stem system of a stool whence, under certain suitable conditions, it grows up into a varying proportion of the canes, which, as a result, may die prematurely. Canes may show symptoms of

* Reprinted from the R.H.S. Report of the Conference on Cherries and Soft Fruits, 1935, by permission of the Council of the Society.

attack at any stage in their development. Thus young growing spawn-canes may suddenly wilt and die from June onwards. Such canes develop a characteristic blue stripe on the stem which later completely girdles it. But more generally premature defoliation of new canes takes place late in the growing season proceeding from the base upwards and preceded by characteristic interveinal and marginal "scorching" and upcurling of leaflets. Canes showing these symptoms may die at any time from shortly after the first appearance of the symptoms until just before cropping time in the next year. The whole cane may be killed, or only a sector of the cane and the corresponding leaves and laterals. An illustrated detailed description of these symptoms has been published.*

Control Measures.

Advice regarding the control of this disease is largely negative in character. Spraying is useless: the fungus being inside the wood tissues is inaccessible and the spore-producing organs of the fungus have never been observed on the aerial parts of stools under plantation conditions, the disease spreading mainly through the soil and by the routine division, transport, and replanting of infected stools. Experiments have shown that no appreciable control is obtained by cutting out canes showing the symptoms or by digging up and destroying infected stools, for it does not follow that the stools showing the symptoms are the only ones infected. The development of the symptoms described depends on external conditions (soil and weather), and their non-appearance does not therefore imply freedom of the stools from the causal fungus. An experiment was carried out at East Malling in which (*a*) stools showing cane symptoms and (*b*) stools free from cane symptoms were divided and planted out side by side for comparison. An equal proportion of vigorous healthy canes was produced from each set of stools. Finally, the proportion of affected canes in any one season depends largely on seasonal weather conditions, being greater in hot dry seasons than in the milder seasons, and it does not therefore follow that a plantation which is severely attacked one year will be more severely attacked the next year. It is quite possible that during the season following a severe attack, no trace or only a small trace of cane symptoms will appear.

It is only rarely with Lloyd George that, in an otherwise healthy plantation, the canes are sufficiently reduced in number by this disease seriously to impair that plantation. In exceptional cases where the disease is persistently serious, all that can be recommended is to try other varieties of raspberry to find one more resistant to the disease under the particular set of conditions in question.

2. Dwarf-lateral Scorch, Black Root-rot and Crown-rot.

In certain seasons (of which the present season of 1935 is an outstanding example) a large proportion of the fruiting canes in well-grown plantations of Lloyd George and other varieties die back in the Spring, during May and thereabouts. The buds on affected canes either wither and die shortly after commencing to push out, or, more typically, form dwarf laterals complete with miniature flower buds, and with the older leaves strongly down-curled and interveinally scorched; frequently the whole cane dies prematurely. In extreme cases the leaves of the young spawn canes are also marginally curled and interveinally scorched and stools may die out completely. In advanced stages localized blackening of the tissues of the crowns and roots of affected canes may occur, and in these regions small white fungus fructifications (*Fusarium* sp.)

* Journ. Pom. and Hort. Sci., Vol. IV, June 1925.

are commonly found on lifting the stools. Investigations have so far, however, indicated that this diseased condition of stools is *not* primarily brought about by this or any other organism but is primarily non-parasitic and therefore non-infectious, being induced solely by an unfavourable sequence of soil and weather conditions, e.g. extreme drought followed by excessive rainfall (cf. nutritional " leaf-scorch ", below).

Control Measures.

(*a*) As this disease is non-infectious there is nothing to be gained and much to be lost by immediately grubbing affected canes and stools, for

(*b*) Observation has shown that stools which survive the two months following the Spring commencement of cane growth, subsequently completely recover and, given favourable conditions, will resume normal cropping the following season.

B. *Diseases and Pests which inhibit the Normal Development of one or more Fruiting Laterals.*

The diseases in the present group differ from those in the foregoing in that the injury to fruiting laterals common to them is due to local lesions or wounds formed on the affected laterals themselves or on the adjacent part of the main cane-stem, whereas any damage to the laterals by group A diseases originates in the underground root-stem system.

1. Cane-spot—a fungus disease. (*Elsinoë veneta.*)

Minute dark spots appear on all parts of young canes infected by cane-spot at any time from the latter part of May onwards. Those on the stems later increase in size and become sunken, forming little dark bordered pits which, if the spots are sufficiently numerous and crowded, eventually coalesce or run together, forming irregular cankers. Infections which take place after the growth of the canes has ceased remain minute in size and unsunken, and it is on these spots that the spores are produced which infect the next year's canes. Appreciable damage is caused to the canes only when the early infection-spots or pit-lesions are very numerous and concentrated, when the canes will become more or less stunted and contorted in growth, and a varying proportion of the buds will either fail to grow out into laterals, or will produce stunted laterals which may wither before cropping. In very severe attacks a part of the cane may die from the tip downwards. In addition to the cane, this disease can also directly attack the fruit, for which phase see below. A more detailed account of these symptoms with illustrations has been published elsewhere.* In this paper a list of varieties highly susceptible to the disease is given, among which Lloyd George is not included because at the time (1931) there was no evidence that it was appreciably susceptible to damage. In subsequent seasons, however, cases have occurred and have become increasingly frequent of severe attacks of cane-spot on this variety, indicating beyond doubt that its susceptibility is becoming greater and that growers of Lloyd George should now be prepared to apply routine control measures against this disease. That such increase in susceptibility is not directly due to the weakening of stools by mosaic disease is evident from the fact that one of the most serious attacks of this disease hitherto seen on Lloyd George occurred in East Sussex in a plantation of mosaic-free canes.†

* Journ. Pom. and Hort. Sci., Vol. IX, June 1931.

† The writer is indebted to Mr. G. C. Johnson for drawing his attention to this case.

*Control Measures.**

This disease, as well as the spur-blight disease, can be reduced in intensity by removing and destroying heavily infected canes during the routine thinning, or can be completely eradicated from a heavily infected plantation by sacrificing the crop for one year, cutting down and burning all the fruiting canes before the new canes appear in early April. (See also Raspberry Moth Control, below.) In most instances, however, and unless the elimination of spur-blight and raspberry moth is also required, such a drastic measure will not be necessary, as it has been shown that the disease can be adequately controlled by two routine sprayings every year with lime-sulphur or Bordeaux mixture as follows :

Stage of Application.	Lime Sulphur.	Bordeaux Mixture.
1. *Delayed Dormant.* When fruiting-cane buds have pushed out not more than ½ inch ..	1 in 15	12 : 12 : 100
2. *Pre-blossom.* When the first flower buds are just showing white	1 in 40	6 : 6 : 100

It is most important that the spraying should be carried out regularly every season, as the efficacy of the treatment is largely cumulative. If this is done and unless control of spur-blight is also required (see below), the second or pre-blossom spraying may be omitted after the first year and adequate control will still be maintained. The " delayed dormant " application is particularly easy to make, as access to the fruiting canes is not obstructed at this stage by the presence of the young canes, and for cane-spot control it is not necessary to spray the latter but merely to cover the fruiting canes thoroughly with the wash.

2. Spur-blight—a fungus disease. (*Didymella applanata.*)

Infections by this disease, as with cane-spot, result in the appearance of localized lesions which, however, are more extensive than those of cane-spot. Thus, whereas it takes many cane-spot infections (pit-lesions) to inhibit the growth of a lateral, a single infection of the spur-blight fungus, if it takes place sufficiently early in the season, will prevent a bud growing out the following year into a fruiting lateral. A single infection of this disease on the surface of the young cane forms a dark blue or brown blotch, which grows until it is an inch or more long and completely girdles the cane. If the lesion of an early infection encircles the base of a leaf, the bud in the axil of that leaf will not grow out the next year. As the cane changes from green to its mature brown colour, these infection patches become silvery white and little black dots appear on them. These are the fungus fruiting-bodies which will later discharge the spores for infecting next year's canes. Fortunately, hitherto, although one or more infection patches are frequently found on Lloyd George canes, plantations in which the attack is sufficiently severe to be regarded as economically serious have been extremely rare in this country. Until 1932 the writer had not observed a plantation thus damaged by this disease alone, but during the Summer of that year his attention was drawn by Mr. G. C. Johnson to a plantation of Lloyd George in East Sussex, the crop of which had clearly been drastically

* In all experiments on cane-spot control carried out by the present writer varieties other than Lloyd George were used. More recently, however, Rhodes in East Sussex has obtained satisfactory control by similar methods on this variety. See The East Sussex Farmer, Vol. I, No. 3, January 1934, pp. 143-6.

reduced by a heavy attack of spur-blight. This attack was of an exceptional nature in that the crop was reduced as a result of the current year's infection rather than, as is more usual, the previous year's infection. During the year in question the main infection took place exceptionally early and before the fruiting laterals had fully grown out, and the brunt of this attack fell on the laterals themselves, with the result that a large proportion were killed before cropping.

Control Measures.

Cases of severe attack of this disease being comparatively rare, very little work on direct control measures has been carried out in this country. The drastic measure for eliminating this disease by the sacrifice of one year's canes has already been mentioned in connection with cane-spot control. The experiments at East Malling on cane-spot control have further shown that if the new canes are also well sprayed at the *pre-blossom* stage some measure of control of spur-blight is also obtained. It is clear, however, that such a spraying would have been too late to be efficacious against the attack on the fruiting laterals mentioned above.

In North America, where serious economic attacks on the red raspberry are of common occurrence, a very comprehensive study of this disease and its control has been made by Dr. W. Koch of the Dominion Laboratory of Plant Pathology, at St. Catherines, Ontario, the result of which has recently been published.* The present writer has recently returned from a period of residence at St. Catherines, during which he had ocular demonstration of the complete effectiveness of the routine spraying used and recommended by Dr. Koch. This consists of spraying the *young canes* with Bordeaux mixture (3 : 5 : 40 plus spreader) when they are 5 inches to 9 inches high. In certain circumstances a second application is made two weeks later. There is no reason why the above treatment should not be applicable to Lloyd George plantations in this country and we intend to try it if a suitable opportunity presents itself.

3. Raspberry Moth or Red Bud Maggot. (*Lampronia rubiella* Bjerk.)

This pest is of serious economic consequence in certain parts of the country and has recently been the subject of special study by Mr. W. Steer, of this Station, who has also found a simple and effective means of control.

The symptom of attack is sudden wilting of young developing fruit laterals in the early Spring, when they have grown out about an inch, which is brought about by the larvæ (or red maggots) of the moth boring into the stem of the young laterals. Here, if left to its own devices, the larva pupates and the resultant moth lays its eggs in the open flowers. The larva of this new brood feeds on the developing fruit without, however, seriously damaging it, after which it migrates to the soil and hibernates there as a half-grown larva, to emerge again the following Spring and bore into the young laterals.

Control Measures.

The only effective control measure which Steer has so far determined is the simple, if drastic, one of cutting down and burning all one season's fruiting canes before flowering. The efficacy of this treatment mainly depends on the prevention of the deposition of eggs by the removal of all the flowers. As the movements of the moth are extremely localized, a severe epidemic is not likely to develop again in the normal life of a plantation thus treated.

* Phytopathology, Vol. XXI, No. 3, March 1931, pp. 247-87, illustrated.

The present writer is indebted to Mr. Steer for the data upon which the above brief account of the action and control of this important pest is based, a detailed account of which, he understands, is in course of preparation for publication.

C. *Diseases and Pests which directly attack the Berries.*

1. The Raspberry Beetle. (*Byturus tomentosus* Fabr.)

The ravages of this pest are too well known to need description here, as is also Steer's work on its life history and control by means of wet sprayings and dustings with derris-root preparations. In accounts of field experiments carried out in 1932 and 1933, Steer shows that satisfactory control of this pest can be obtained on the Lloyd George raspberry by one spraying (instead of the previously recommended two sprayings) of a derris wash applied in normal seasons towards the end of June.

The wash used is made up as follows :

Finely ground derris-root	2 lb.
Soap	5 lb.
Water	100 gals.

In the raspberry there is considerable latitude as to the date of application. The efficiency of control normally obtained by this simple treatment is in the neighbourhood of a 90 per cent. reduction of the injury caused by the beetle.

2. Direct attack of Berries by the Cane-spot Fungus.

Under certain seasonal weather conditions the main discharge of infecting cane-spot fungus spores may be delayed until the berries are forming. This happened in 1932 when the main infections had occurred in late July. As a result exceptionally little damage was done to the canes in that season, but the later maturing berries were often directly infected and became malformed. This phenomenal attack showed that in certain seasons damage may result from the current season's cane-spot infections rather than from the previous year's infections, an additional argument for maintaining *a regular annual spraying* against this disease. (Cf. the analogous case with spur-blight.)

D. *Diseases which sap the Normal Vigour and Productivity of Stools generally.*

The diseases in this, the final group, are distinguished by the fact that characteristically they do not form lesions, or wounds on the canes, neither do they bring about, except in their ultimate and extreme stage, dying back of individual canes. Affected stools, on the other hand, show a progressive diminution in vigour of growth, i.e. dwarfing and stunting of the canes and laterals, with a corresponding reduction in crop, and a reduction in productivity of new canes.

1. Raspberry Mosaic Disease—a virus disease.*

This is outstandingly the most fundamentally serious and insidious disease of the raspberry in Great Britain, as also in North America. In an individual plantation the raspberry beetle or cane-spot may cause greater immediate damage in decimating or completely destroying a crop, and the attention of growers will naturally be focussed

* A virus is an infective principle which can be transferred from diseased to healthy plants but which has so far remained invisible even by aid of the microscope.

on such to the neglect of stools which, apart from an intermittent mottling and curling of their foliage, may otherwise be indistinguishable from their neighbours with normal foliage. Therein lies the insidiousness of a disease which, but for active steps now being taken for its control, would ultimately have rendered the Lloyd George raspberry useless for further commercial cultivation. This conclusion is advanced on the strength of observational and experimental data accumulated over a period of some twelve years' study at East Malling of the reaction of mosaic diseases on Lloyd George and many other varieties, the detailed results of which are in course of publication. A general account of the varying types of raspberry mosaic symptoms in Great Britain has recently been published.* The sole symptom whereby an infected stool can be detected in the plantation is, as has already been hinted, a greenish-yellow mottling accompanied by curling (in varied degree) of the foliage. The appearance of this symptom is intermittent. Thus it is usually not visible on the leaves when they first unfold in the spring but is commonly visible from the middle of May onwards. If the season is hot and dry, suppression of the mottling may take place in the midsummer months with a reappearance in the Autumn. In its incipient stages, the symptoms are often extremely difficult to detect even at the optimum times for diagnosis, as only a few leaves may show them clearly. A form of mottling distinct in origin from mosaic (pseudo-mosaic) may also occur, and may easily be confused with true mosaic. To sum up, the accurate diagnosis of mosaic on such a variety as Lloyd George can only be achieved after long and assiduous practice and constant contact with diseased and normal stools. The subject is further complicated by recent experiments showing that raspberry mosaic is not a simple disease but a complex of distinct diseases. We can infer from this that a given effect on a stool may be the result of the interaction of diseases which singly act on the plant in very different ways and are not equally easy to diagnose.

Finally, with regard to the effect of the disease on the plants. After the initial infection (by natural agents hitherto undetermined in this country†) the disease rapidly permeates the whole plant system, so that any spawn-cane which is in future detached for propagation purposes from that plant is itself infected. Hitherto no case of natural recovery has been recorded, but, on the contrary, from the time of infection a relatively slow diminution in vigour of the plant takes place. This usually slow rate of deterioration constitutes the chief danger of the disease. An extensively infected plantation *may* subsequently go on producing good canes and crops for some seasons, and it has been shown that there is but little advantage to be gained in immediate length of life and cropping by the regular and laborious elimination of mosaic stools from a *fruiting plantation*. But when that fruiting plantation is regarded as the potential source of the cane of *future* Lloyd George plantations, the position is serious, for it has been proved by experiment (1) that mosaic disease is infectious and spreads under natural plantation conditions, and (2) that the vigour of an infected stool and all its progeny surely, if slowly, decreases from the time of infection. The inference from this is that, unchecked, the disease must inevitably infect the whole available Lloyd George cane in cultivation, and when this occurs it can only be a matter of time before the variety ultimately becomes commercially non-productive and useless. This has already occurred in other sometime popular and widely planted varieties, such as Mitchell's Seedling and Superlative. When observations were commenced at East Malling on Lloyd George soon after the Great War, cases of mosaic were only rarely identified in our own plantations and on commercial fruit farms. In recent years it has been exceptional to find

* Journ. Pom. and Hort. Sci., Vol. XI, No. 3, September 1933, pp. 237-55.

† Experiments to determine the natural vectors of raspberry mosaic have been in progress at East Malling for some years, but hitherto have yielded negative results.

a plantation, planted with cane from the ordinary commercial sources, with less than 50 per cent. of the stools mosaic-infected, and we are receiving many enquiries as to why Lloyd George no longer grows with its pristine vigour and productiveness. Thus it is evident that failure to control this spread of mosaic in susceptible varieties must inevitably ultimately imply their extinction.

Control Measures.

A series of experiments at East Malling on the commercial control of mosaic disease in Lloyd George has led to the formulation of a practical system, which is already being practised by growers with conspicuous success, and a brief preliminary account of which has recently been published.* This system recognizes the impracticability of producing first-rate Lloyd George fruit and cane† from one and the same plantation and aims at achieving the control of mosaic disease by permanently ensuring for the grower supplies of cane true to name and free from mosaic disease with which to plant his new plantations. This cane is raised in specially designed propagating beds or " cane nurseries ", laid down and conducted according to the following general principles :

(*a*) They are *planted* in the first instance as far as possible from other raspberries with a special race of mosaic-free cane raised at, and distributed from, the Research Station.

(*b*) *Planned* to facilitate the elimination of all new centres of infection detected by regular inspections and " roguings " twice annually.

(*c*) *No cane is allowed to fruit* in the nursery, all canes, from the first productive year onwards, being dug up at the end of each season, leaving enough root spawn in the ground to furnish the rows the following season.

By the latter procedure newly rooted current year's spawn cane only is distributed, which is also free from such diseases as cane-spot and spur-blight, in addition to mosaic diseases.

In 1930 experimental nurseries on the above principles were established at the Farm Institute and on selected commercial farms in Kent and Sussex. These were inspected regularly from East Malling, and during the five years in which these nurseries have been in operation it has been evident that the extra labour expended in inspecting and roguing them is small compared with their high productivity of uniformly vigorous, healthy and reliable cane, the disposal of which at enhanced price has presented no difficulty.

The subsequent demand from all parts of England and from Scotland for small consignments of tested cane (" cane nuclei ") for the establishment of other cane nurseries has been considerable and difficult of fulfilment, but the main problem raised by such multiplication of nurseries is the lack of administrative machinery for providing growers and nurserymen generally with facilities for that regular series of inspections and roguings of their " cane nurseries ", under expert supervision, upon which the effectiveness of this system for combating the inroads of mosaic disease in Lloyd George, and eventually in other valuable varieties, depends.

In this connection it is interesting to note that in Eastern Canada a scheme for the certification of raspberry cane for a reasonable degree of freedom from disease (virus

* E. Malling Res. Sta. Ann. Rep. for 1932 (1933), pp. 149-51.

† This system will be extended to include other varieties, as necessary and when the requisite data and cane are forthcoming.

disease in particular) is already in successful operation under the auspices of the Dominion Government. This scheme is based on a system of inspecting special nursery rows, similar in many respects to that described above, and all bundles of cane certified under it are distinguished by the attachment of an official brightly coloured " tag " or certificate.

Whilst residing at the Dominion Laboratory of Plant Pathology, St. Catherines, Ontario, whence the certification scheme is administered for this Province, the present writer was greatly impressed by its success and large-scale practicability as evidenced (1) by its widespread acceptance by growers and nurserymen (the great majority of raspberry growers in Southern Ontario will only purchase Government " tagged " cane for planting), (2) by the generally high quality of the cane in commercial circulation, and (3) by the continued successful cultivation of varieties highly susceptible to virus disease.* The need for some such scheme for administering the system of control of mosaic disease now available to (and in process of adoption by) the grower in this country is apparent.

2. Nutritional Disorder in relation to Mosaic.

(*a*) *Leaf-scorch.* " Leaf-scorch ", probably like the previously described " dwarf-lateral-scorch ", is evidence of a diseased condition set up entirely by non-parasitic causes, but whereas the latter is associated with a particular sequence of physical conditions of the soil (such as drought followed by excessive moisture), " leaf-scorch " is brought about by unbalanced nutrition, and, following on the work of Wallace at Long Ashton with other crops, has recently been described for the raspberry (with photographic illustrations) by T. N. Hoblyn in an account of two large-scale field experiments carried out at East Malling on the varieties Lloyd George and Pyne's Royal.† The symptoms in question began to appear on the leaves of the current year's canes in September and its incidence was definitely correlated with a low potash/nitrogen ratio (potash deficiency). In these experiments it was shown that on the East Malling soil although applications of nitrogenous fertilizer (sulphate of ammonia) *alone* might increase the *number of canes* formed from each stool, such applications, in the absence of balancing potash fertilizer, not only failed to raise the crop of Lloyd George berries but indeed actually had a depressing effect upon it.

(*b*) *Effect of Manuring on Mosaic Stools.* The above experiments were imposed on a newly purchased commercial plantation of the two varieties in question, previously planted with cane from the ordinary commercial sources (containing a considerable percentage of mosaic-infected cane), and, unfortunately for the purely pomological issues, the plots soon became extensively infected with mosaic disease. The presence of such a large proportion of mosaic-infected stools on the plots, however, provided a striking example of the commonly experienced interaction of purely environmental or non-parasitic causes (soil, etc.) and parasitic causes, to produce a given pathological result, emphasizing the great importance of allowing for such in field diagnosis. Thus, in the Lloyd George plantation in question, it would have been erroneous to ascribe the extreme dwarfing of the mosaic stools on the plots receiving nitrogenous fertilizers alone (without potash) solely to the action of mosaic disease. For a comparison of such stools with mosaic stools on the parallel plots receiving potash, or potash and nitrogen fertilizers, showed that the dwarfness of the former stools was clearly due in large part to

* A further account of the Canadian Certification Scheme appears in E. Malling Res. Sta. Ann. Rep. for 1934 (1935), pp. 161-2.

† Journ. Pom. and Hort. Sci., Vol. IX, No. 4, December 1931.

a deficiency of potash fertilizer. At the conclusion of the experiments final records of total cane growth were taken in which the measured canes were sub-classified as showing or not showing mosaic symptoms. An analysis of these records showed that although the vigour of growth of mosaic-infected stools was greater under certain manurial treatments than others, that vigour under all manurial treatments was always slightly less than that of the mosaic-free stools receiving the same treatment. It does not necessarily follow, therefore, that poor cropping of an extensively mosaic-infected Lloyd George plantation can be *entirely* ascribed to mosaic disease. It may be due, in part, to unbalanced manuring, and the application of the appropriate fertilizer may result in a great improvement of growth and cropping. The point to bear in mind, however, is that whatever improvement is brought about by the modified manuring of an extensively mosaic-infected plantation, that plantation can never be made to crop as efficiently as a similar plantation from which mosaic disease is absent or only present in negligible proportion ; and that in the course of subsequent propagations and re-plantings this inevitable discrepancy between the performance of healthy and mosaic-infected stools will increase from being slight at first until ultimately the plantation will cease altogether to yield commercial crops however the manurial programme is modified.

III. The Variety Question.

It can be concluded from the above survey that at the present time intelligent application of certain routine measures in disease control is essential for the maintenance of the commercial efficiency of the Lloyd George raspberry. Neglect of it must inevitably result in the ultimate loss of this important variety to commerce, with all the inconveniences of a long transition period of decline before it is finally discarded. Precisely the same principles apply to all other commercial varieties with slightly differing emphases on some of the diseases, and in certain cases the inclusion of one or two others. Thus, in conclusion, we come to a brief consideration of that basic method of disease control, the growers' choice of varieties in relation to their resistance to, and/or their low infectability by, disease. Lloyd George on its introduction some fifteen years ago took the raspberry-growing industry by storm on account of its combination of exceptional vigour, fruit quality, and an apparent high resistance to disease under a wide range of soil conditions, to the temporary obscuring of other varieties. More recently, and as we have seen in the foregoing section, this high resistance to disease has proved to be more apparent than real, and the undoubted limitations of this variety increasingly emphasize the need of a greater range of similar first-rate commercial varieties from which to make selection.* In North America, where the range of external conditions under which raspberries are grown is extremely wide, the raspberry grower has a correspondingly large range of varieties from which to select and rarely depends on a single choice. Unfortunately it does not follow that the most desirable fruit and cane qualities are combined with equally desirable factors of disease resistance. Thus in North America, one of the most popular varieties from the Atlantic to the Pacific for fruit quality—the Cuthbert red raspberry—is also outstandingly susceptible to virus disease and to winter injury, and the fact that it is still widely and successfully grown is an effective tribute to the Dominion Government certification scheme.†

* In the recent frost of 16th May, certain varieties were conspicuously less seriously affected than Lloyd George.

† The interesting raspberry disease situation in North America with particular reference to virus disease and the variety question, and in relation to our own raspberry problems in Great Britain, has been described by the present writer in a recent article. E. Malling Res. Sta. Ann. Rep. for 1934 (1935), pp. 156-64.

One of the most striking distinctions between varieties throughout the extensive collections at East Malling and elsewhere has been in respect of their differing susceptibility to disease. But whereas relative susceptibility to such diseases as blue stripe wilt, cane-spot, spur-blight, etc., appear to be only to a small degree dependent on locality (e.g. Baumforth's Seedling B is highly susceptible to cane-spot wherever it is grown), only in one instance, that of Red Cross, has a variety been observed to be highly resistant to mosaic wherever it is grown commercially. Red Cross has been observed at East Malling and in many other localities ever since the commencement of the variety collection shortly after the Great War and during this period every stool observed has shown symptoms of mosaic infection, but no indication has yet occurred of any general deterioration of this variety in vigour and cropping as a result of such infection, and it still remains among the best croppers at East Malling. Other varieties, an outstanding example of which is the well-known Scottish variety Mitchell's Seedling, exhibit in certain localities a high degree of resistance to the deteriorating action of the mosaic virus for a number of years after all their cane has become infected, but when moved to other localities rapidly succumb to the virus and go out of cropping.

The above outline of some of the problems involved in the important matter of selecting varieties is perhaps sufficient to indicate the important field of work open in the breeding of new varieties of raspberry in relation to the control of raspberry disease.*

* For an account of certain suggestive results obtained by North American workers in this field, see article referred to in preceding footnote, p. 240. A progress report of recent raspberry breeding work by Grubb at East Malling will shortly be published in the Journ. Pom. and Hort. Sci.

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